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The Role of "Sense of Place:" A Theoretical Framework to Aid Urban Forest Policy Decision-Making

Kimberly Louise Davis
University of Tennessee - Knoxville, kdavis17@utk.edu

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Robert Emmet Jones, Major Professor

We have read this dissertation and recommend its acceptance:

R. Scott Frey, Thomas C. Hood, Suzanne B. Kurth, Joanne Logan

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

THE ROLE OF "SENSE OF PLACE:" A THEORETICAL FRAMEWORK TO AID URBAN FOREST POLICY DECISION-MAKING

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DEDICATION

This Doctoral dissertation is dedicated to my father, Robert E. Davis.

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ABSTRACT

Urban forest management is being increasingly recognized as a viable policy vehicle for improving the overall quality of life in urban regions, promoting economic well-being as well as mitigating some of the environmental impacts of urbanization. As a complex system of ecological merit, the urban forest is ultimately dependent upon community-directed efforts to protect and maintain its health, largely through tree ordinances. An understanding of how values and other social factors trigger public concern for and management of the local urban forest is important because of ramifications of community urban forestry policy on regional ecosystem functional capacity. This dissertation investigates the influence of individual experience with trees, knowledge about trees, and tree-related attitudes and beliefs on public support for management strategies to protect the urban forest. Attitude theory forms the foundation of the empirical approach used in this study. Drawing from place theory, attitudes representing *Sense of Place* were hypothesized to also play a role in explaining variation in homeowners' support of urban forest protection strategies. Data were obtained from a public opinion survey of 800 homeowners living in a major urban area in Southern Appalachia and joined with measurements of tree canopy density. Geographic information systems software was used to create measures of tree canopy density from Light Detection and Ranging data for varying aerial extents around the survey respondents' properties. Theoretical constructs were formulated and deployed in structural equation models to test the validity of the hypothesized relationships among the constructs, representing predictors of public support for urban forest protection policy. The modeling results showed that place-based contexts are significant in the prediction of community willingness to support higher levels of urban forest protection. Findings from this study suggest that although the presence of urban trees in one's neighborhood leads a homeowner to place greater importance on various attributes of trees, this does not automatically lead to support for strong tree ordinances. One also must have a basis of attachment to tree places, which is predicted by tree knowledge and experience with caring for trees around one's home. In conclusion, limitations and suggestions for future research are provided.

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CHAPTER I

INTRODUCTION

This dissertation research uses environmental sociological theory to construct firmly grounded analyses of the interconnection among nature-society relations and place relations. In order to carry out a meaningful analysis of this linkage, I have focused on public concern for the protection of trees in the urban environment. As a major global icon of terrestrial nature conservation and nature destruction, urban trees serve as visible indicators of quality of life and transformation of cities and the human-built environment. As part of the “urban forest,” trees serve vital functions in our cities, such as increased energy savings, improved air quality, aesthetics, health benefits, habitat for birds and other wildlife, and recreation enhancement (Dwyer et al. 1992). Moreover, urban trees are becoming increasingly important as the proportion of the population that is urban-dwelling grows. With an average tree cover of 33 percent, metropolitan areas in the United States (U.S.) collectively support nearly one quarter of the nation’s total tree canopy cover—some 74.4 billion trees (Dwyer et al. 2000). However, research conducted by the Urban Forest Center at American Forests found that the urban tree cover plummeted in all 25 metropolitan areas that were studied and that three dozen American cities lost more than one-fourth of their tree canopies since 1972 (Lin 2007). The threat to the health of U.S. urban forests brought on by the intense pressures of the urbanization process has the potential to dramatically change the relationship between human society and the natural environment.

Efforts to address the threats to the urban forest began to increase in the last two decades of the 20th century, through the emerging awareness in progressive communities of the usefulness of tree ordinances for promoting environmentally sustainable development. In the quest to strike a balance among the environmental, aesthetic, and economic implications that tree protection legislation entails, there has been increasing interest in the relationship between local community values and public support for such government initiatives. The current study examines whether the willingness of citizens to absorb the costs of tree canopy protection policies may correspond with place-specific valuation engagement of landscapes with urban trees, represented in part by socially-constructed meanings of the urban forest. Put simply, this research asks whether physical place matters in the prediction of public preferences for urban forestry programs. A better understanding of the influence of socially produced landscape values on public acceptance of local urban forestry objectives and practices has the potential to improve the health and connectedness of the U.S. urban forest resource as a whole.

In order to explore public concern for the local urban forest, theoretical precepts embedded in place theory were related to concepts traditionally explored in social-psychological studies drawing from attitude-behavior theory. An important question explored by the research is how *Sense of Place* (SOP) mediates the influence of life experience and knowledge on support for government initiatives to protect the environment, with an emphasis on urban forestry policies. Using data collected from a 2006 case study of Knox County, Tennessee homeowners, hypothetical constructs were developed representing knowledge, experience, beliefs, attitudes, and support for the maintenance and protection of that community's urban forest. Geographic information systems (GIS) software was used to develop spatial data in the form of tree canopy density to be used as an indicator for place-based contexts. The objective was to examine whether variation in support for tree maintenance and protection policies (as measured from social survey data) may be attributed to the place-based contexts that make up *Sense of Place*. The hypothesized intersection of place theory and attitude theory is viewed as an opportunity for the exploration of a number of research questions related to spatial distribution of environmental values, their relationship to SOP, and how spatial data may be analyzed to link biophysical factors with public perception of urban forests and support for their protection.

Significance of the Study

Urban forestry is increasingly recognized as a viable policy vehicle for improving the overall environmental quality of life in urban regions, promoting economic well-being, and mitigating some of the environmental impacts of urbanization (Wolf 2007, Rowntree 2008, Dwyer et al. 2000, Carreiro, Song, and Wu 2008). However, urban forestry differs from many traditional forms of natural resource management due to its heightened "social character" resulting from visibility to the general public and potentially opposing viewpoints reflecting the many values, norms, and interests of local community members (Konijnendijk 2000). This social character lends itself to the study of the structure and function of the urban forest at different spatial scales, beginning with processes that govern human interactions with individual trees at the smallest scale, moving up through progressively larger scales: the block, neighborhood, planning district, city forest, urbanized area forest, and finally the region (Ekbia and Evans 2009, Rowntree 2008). This research is important because it focuses on individual homeowners and how socio-material aspects (e.g., their subjective opinions about trees) may translate into support for local environmental policy that eventually leads to diverse ecological outcomes on larger scales.

Since the time of Durkheim, sociologists have acknowledged the significance of physical settings of social interaction and the way that the experience of a place is socially constructed. However, the perception that material conditions of place directly predict environmental attitudes and behavior is a gross over-simplification of how humans interact with their physical setting (Gieryn 2000, Stedman 2002, Stedman 2003a, Stern 2000). With roots in phenomenology and interactionism, the use of a constructionist perspective for place theorizing in sociological research has evolved in response to, and as a critique of, potential "ecologically deterministic" distortions of how humans experience and react to the world. In fact, this is the debate that led to the formation of environmental sociology as a distinct discipline in the first place: a recognition that humans are not exempt from constraints set forth by the biophysical environment (Buttel 1987, Dunlap and Catton 1979). As place is, at once, physical objects assembled at a certain geographical spot and actors' interpretations, representations, and identifications, both domains (the material and the interpretive) may end up working simultaneously in a self-governing and in a mutually dependent way (Bourdieu 1990 in Gieryn 2000).

The research undertaken for this dissertation is significant for two reasons. First, it combines important aspects of attitude theory and place theory to address the interplay among the physical environment, life experience, knowledge, SOP, and "place protectiveness" (as depicted by support for environmental policy). It tests a model that integrates and systemizes the following related prongs of previous research: (1) factors that make up SOP as described by place theory and (2) how SOP mediates social structural factors' linkage to support for environmental policy, and (3) how specific biophysical characteristics of the landscape, in the form of urban trees, play a role in predicting public support for protection of the urban forest. Second, findings from this research will enable elaboration on how GIS technology and its diffusion may play a transformative role in better understanding the effect of SOP on community attitudes toward tree canopy protection on the community level. This has important implications in the ability of urban forest managers and other land use planners to trace social, ideological and ecological configurations of ecosystem health on a regional scale, due to the connection of urban forests to periurban and exurban forests.

Theoretical Overview

Beginning with Dunlap and Van Liere's (1978) New Environmental Paradigm scale which measured environmental attitudes, environmental sociologists have been refining, expanding, and applying similar theories in their examination of human environmental actions such as recycling and energy conservation, as well as "non-activist" behaviors such as citizen willingness to incur personal costs by supporting policies designed to promote environmental sustainability. Social theorizing using attitudes to predict environmental behavior is often carried out in problem-oriented context. Examples include: applied behavior analysis examining individual reaction to specific perceived environmental problems (Cottrell 2003); evaluative research on environmental concern about potential risks to the environment, such as global climate change or overdevelopment of natural areas (Zahran et al. 2006, Devine-Wright 2009); and systematic observation and measurement to describe public opinion about environmental policy intervention, such as willingness to pay for government programs (Stern, Dietz, and Kalof 1993). The underlying goals of these projects are to identify drivers of behavior, behavior intentions, acceptance of environmental policy, and environmental attitudes in general, then develop sound sociological theory that helps to gain an understanding of these outcomes in order to suggest positive change.

The environmental "problem" examined in the current research is the declining urban forest canopy. It is designed to: (a) empirically test theoretical propositions by environmental social scientists on the determinants of environmentally significant attitudes and behavior with regard to urban trees; (b) introduce an external variable, urban tree canopy density, for understanding place-based identities based on shared meanings of tree places; (c) develop and analyze a more fully specified model predicting willingness to support urban tree protection and management policies; and (d) show how GIS may help bridge the gap between qualitative, place-based meanings from a social construction standpoint and a quantitative approach that allows the inclusion of place-based factors in an empirical analysis of drivers of community support for environmental protection policies.

Outline of Dissertation

Chapter 2, the review of the literature, begins with an overview of the mostly atheoretical work examining the human dimensions of natural resource management (NRM), with its emphasis on how place meanings and identities influence community acceptance of proposed landscape management policies. This work is oriented toward largely qualitative case studies of how place-based, participatory approaches are used by planning agencies to facilitate building consensus among stakeholders during environmental policy discussions. NRM research examines how experience with various "ecological features" in peoples' everyday lives leads to shared landscape preferences, land management goals and activities, through the development of a *Sense of Place* through the meanings and attachments individuals or groups have for a spatial setting (Cheng and Daniels 2003). NRM research often deals with naturalized and rural settings, but it provides the framework for studies of the human dimensions of the urban forest, which is discussed next.

The second part of Chapter 2 focuses on the application of social theory to urban forestry. First, the foundations of attitude-behavior are discussed in the context of literature on environmental concern, which uses a "cognitive hierarchy" to link social structural factors, beliefs, attitudes, and behavior. The chapter proceeds to review the empirical research that has taken place recently using public opinion surveys to examine relationships among attitudinal constructs and support for public policy to protect the urban forest. Next, the concept of *Sense of Place* as used by place theory is reintroduced as a complement to sociological theorizing, and is linked to environmental concern attitude-behavior literature through a common emphasis on a "tripartite" conceptualization of attitudes (i.e., affective, conative, and cognitive). Richard Stedman's (2002, 2003a) work linking *Sense of Place* presents *place attachment* and *place satisfaction* with landscape features, place meanings, and "place protectiveness" as the basis for merging common elements of attitude-behavior theory and place theory. His cognitive hierarchy model provides theoretical justification for including measurement of urban tree canopy density in the current study as a variable potentially influencing a sense of "place protectiveness" for the local urban forest. The chapter concludes with a discussion of the use of GIS in social spatialization literature to measure biophysical features of the landscape as predictors of values and preferences.

Chapter 3 begins with the presentation of the hypothesized model used in the current study, as synthesized from theorizing in the environmental concern literature and studies relating *Sense of Place* to environmental attitudes, landscape qualities, and support for environmental protection. Five hypotheses are discussed that pertain to the structural configuration of this model.

Chapter 4 presents the methodology of the dissertation, including details about the data set used in the research. The first section includes a description of data collection procedures, the study area, and the conception and design of the study survey instrument. Socio-demographic characteristics of the respondents are described. Scale items used to form the study constructs are presented and related to specific questions from the questionnaire. Next, details are provided with regard to the Light Detection and Ranging (LiDAR) data and how GIS was used to calculate tree canopy density, a variable used in the study model. The chapter concludes with an overview of the structural equation modeling (SEM) analysis procedures that were used to test the hypothesized model.

Chapter 5 presents the results of the data analyses. An overview of the "two-step" approach used in SEM is discussed. Step 1 of this approach uses confirmatory factor analysis to determine convergent validity of the study's constructs individually. Discriminant validity is checked by constructing a measurement model, where a covariance is estimated to connect each latent variable with every other latent variable. In Step 2, the measurement model is modified to include unidirectional paths between the latent variables as depicted in the hypothesized model. Parameter estimates for significant direct and indirect relationships are presented as well as an extensive discussion of statistical output and the implications for model fit. This chapter concludes with a discussion of study hypotheses and an interpretation of how well the findings supported them.

Conclusions are summarized in Chapter 6 after briefly reiterating the study purpose and justification for the theories used to develop the theoretical model. Following this first section, implications of the findings for urban forest policy decision-making are discussed. In particular, the role of spatial analyses is promoted as a methodological tool to achieve a more holistic approach for gaining an understanding of the multi-scalar nature of human-ecological functioning. Recommendations for future work are given that build on this study's incorporation of *Sense of Place* constructs in the cognitive hierarchy approach to relating knowledge, experience, attitudes, and beliefs to support for urban forest protection.

CHAPTER II

LITERATURE REVIEW

The principal objective of this chapter is to provide a comprehensive and critical review of studies that form the theoretical and empirical basis for the hypothesized model presented at this chapter's conclusion. A theoretical framework is developed that relates three major prongs of previous research: (1) the largely atheoretical body of literature encompassing natural resources management for practitioners, (2) attitude theory, and (3) place theory.

Since the purpose of this dissertation is to use social theorizing to clarify the human dimensions[1] of urban forest protection policy, it is necessary to first explore broader research in the field of natural resources management which examines how physical *place*[2] mediates social-psychological factors in prediction of support for government initiatives to protect the environment. The process of developing sound ecosystem management strategies relies not only on accurate scientific information that supports "technocratic" approaches to land policy decisions (e.g., designation of areas to plant certain types of trees), but also on a thorough understanding of attitudinal and place-based factors (e.g., local knowledge, beliefs, and values) that serve to democratize the scientific process through recognition of different legitimate perspectives on environmental policy measures (Funtowicz and Ravitz 1993).

Next, I focus on the role of attitude theory in the literature examining the relationship among values, beliefs, concern, and behavior, and how *Sense of Place* (SOP) theorizing flows from the "tripartite" characterization of environmental attitudes (i.e., cognitive, conative, and affective components of attitudes that define the relationship between people and places). Attitude theory emphasizes the important role public concern for the environment (i.e., "environmental

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[1] As defined by a National Research Council study, the "human dimension" is the "rich mixture of cultural practices, social interactions, and human feelings that influence the behavior of individuals, social groups, and institutions"(Stern and Aronson 1984).

[2] "Place" is most commonly defined as a physical space imbued with "meaning" (Low and Altman 1992:5), where biophysical attributes and processes, social and political processes, and social and cultural meanings come together (Cheng and Daniels 2003).

concern”) plays in understanding and predicting individual and collective actions to improve environmental quality (Dunlap and Jones 2002, Routhe, Jones, and Feldman 2005). Place theory uses attitude theory as a basis for the development of the concept *Sense of Place* to represent the centrality of spatial conceptions in empirically specifiable “social products” of human perception, values, and feelings. Often conceived as another form of “attitude,” SOP presents the opportunity to establish linkage between place theory and attitude theory with tested research methods when evaluating relationships between humans and natural environments. I propose to use social theory to gain a better understanding of how these attitudinal factors interrelate to identify a community’s place-based motivations and inclinations with regard to support for natural resource management strategies aimed at protection of the local urban forest canopy.

The review of scientific literature is organized into two sections. The first section presents a background of urban forestry, and is introduced with a discussion of broader studies encompassing identification and proposed predictors of public support for natural resources management strategies. The second section outlines the development of attitude theory and place theory in an ecological context, opportunities for synthesis between these two theoretical frameworks, and examples in the literature of empirical approaches using geographic information systems (GIS). The chapter concludes with a summary of the current research.

Public Concern for Urban Trees

Although there is a large and expanding body of research that examines environmental concern in general (Dunlap and Jones 2002), there are a limited number of in-depth, peer-reviewed studies that deal directly with public concern for the maintenance and protection of urban trees in the United States. To gain a better understanding of this area, it is necessary to first review broader studies considering environmental management strategies for natural areas from a macro standpoint, as well as studies that focus more on “micro-spatial” aspects of human social-psychological perceptions of certain environmental features of their surroundings, such as natural forests, urban green spaces (e.g., parks) and street trees (Lalli 1992). The lack of social research on public concern for urban trees specifically is not necessarily for lack of interest, but probably due more to the tendency of new research to build on previous studies examining more wide-ranging landscape features that “fit” varying theoretical perspectives and empirical approaches afforded by a number of disciplines. This epistemological and methodological diversity of previous work in environmental concern creates a challenge to relate these cross-disciplinary studies in such a way that development of theory may proceed through in a meaningful way from a sociological point of view.

In the subsections below, contributions from research in human dimensions of natural resource management (NRM) and urban forest management are reviewed. Much of the NRM literature that is applicable to this dissertation research examines case studies of “place-based” approaches to encourage collaborative planning. This literature is of interest because environmental sociologists also apply similar social constructionist perspectives that explore common symbolic meanings of landscape features among different groups of people (Berger and Luckmann 1966, O’Brien 2006, Greider and Garkovich 1994, Stedman 2003b). In addition to presenting a general overview on urban trees in the U.S., a large part of the urban forestry literature discussed is devoted to how trees contribute to making of “place,” research that has taken place to assist urban foresters, and formation of policy to protect trees. It is hoped that this overview will help the reader conceptualize the potential theoretical and practical contributions of perspectives offered by social research in attitudes, environmental concern, and *Sense of Place* discussed later in this chapter.

Natural Resources Management

An expanding body of research exists in the human dimensions of natural resources management which uses qualitative research methodologies to examine place-based values as a framework for devising land management strategies. These are largely atheoretical, pragmatic applications of how geographic factors influence beliefs, attitudes, and behaviors in ways that result in variations across space, sociocultural groups, and political boundaries (Larson and Santelmann 2007). Geographic research highlights the importance of local context in natural resource management, given unique patterns and relationships among physical and human elements of the landscape. This local context is expressed by landowners in how they value[3] and treat the landscape. Managers can then examine this local context in order to learn more

[3] NRM research interchangeably defines “value” as either “held values” in a general aesthetic sense (e.g., one values a park because it is beautiful) or “assigned values,” which are more utilitarian and comparative (e.g., the relative worth of a tract of land as a recreational or timber resources). The two are not independent and it has been argued that assigned values reflect a person’s held values (Tarrant and Cordell 2002).

about how to effectively initiate dialogue, frame negotiations, and interpret action alternatives for accommodating sustainable economic activity that includes tourism, forest recreation, natural resource harvesting, and residential and commercial development.

Sociologists have long studied how people form mental constructs that allow them to understand environmental problems, as well as how environmental knowledge is appropriated, constructed (framed), and deployed by powerful actors in our society who stand to benefit from shaped perceptions (Buttel 1994 in Redclift and Woodgate 1997). The concept of place is also a social construction: humans, acting as social agents, bring meaning to their environment by identifying concepts such as place, setting, community, or region (Brown 2005). NRM research takes a pragmatic approach to explore how the *Sense of Place* construct impacts values, attitudes, and policy outcomes. In this way, the social construction of the reality of one's physical environment reveals that landscape meanings are symbolic reflections of how people define themselves and the environment.

When attempting to identify and understand the potential human consequences of changes in the natural environment, it is imperative that these consequences are understood from many cultural definitions of landscapes (Greider and Garkovich 1994). Through interpretive research into place-based meanings, place identity, and perceptions that people ascribe to natural areas, many NRM studies focus on gaining an in-depth and integrative understanding of overarching issues such as improvement of regional watershed quality and sustainable forest management (Measham 2006, Cheng, Kruger, and Daniels 2003, Cheng and Mattor 2010, Larson 2010, Brody, Highfield, and Alston 2004, Norton and Steinemann 2001, Larson and Lach 2008, Cheng and Daniels 2003). Increasingly, traditional expert-driven, top-down decision processes in this arena are being replaced with more participatory approaches that build on values of stakeholders, their land ethics, and *Sense of Place* that originate locally as intangible "shared ways of knowing" (Cheng and Daniels 2003). Thus, effective NRM policy implementation depends on broad-based consensus that allows for the evolution of knowledge shared by all of those who are most affected by decision-making for ecological management.

A common theme in NRM research is "place identification" which involves symbolic reflections of how people define themselves. Proshansky, Fabian, and Kaminoff (1983) defined the concept of *place identity* as:

> …a substructure of the self-identity of a person consisting of, broadly conceived, cognitions about the physical world in which the individual lives. These cognitions represent memories, ideas, feelings, attitudes, values, preferences, meanings, and conceptions of behavior and experience that relate to the variety and complexity of physical settings that define the day-to-day existence of every human being. At the core of such physical environment-related cognitions is the 'environmental past' of the person; a past consisting of places, spaces and their properties which have served instrumentally in the satisfaction of the person's biological, psychological, social, and cultural needs. (p. 59)

Cheng and Daniels (2003) use the term "ways of knowing" to describe a *Sense of Place*, which they propose leads to a place-based group identity. This, they claim, is key to improving collaborative working relationships in NRM conflicts. In their qualitative study of the Mohawk Watershed Planning Group in western Oregon, they found that the articulation of place identity was critical for success in collaborative planning. By defining potential transformation of the physical environment in terms of how it impacted stakeholders' definitions of themselves, the sociological framework of landscape emerged as a vehicle for gaining a better understanding of the level of renegotiation that would be required of stakeholders' relationship to the environment in terms of changing definitions of themselves (Greider and Garkovich 1994).

Place meaning flows from place identity through its reciprocal character: similar to place identity, place meaning informs us of who we are, but it also guides our experience and behavior in relation to those settings (Williams and Vaske 2003). In general, place meanings encompass instrumental or utilitarian values as well as intangible values such as belonging, attachment, beauty, and spirituality (Low and Altman 1992, Cheng et al. 2003). Davenport and Anderson (2005) theorized how shared place meanings may add depth to decision-making processes for management of the Niobrara National Scenic River in north central Nebraska, which was facing increased recreational use and the expansion of tourist-related services and accommodations. They interviewed 25 residents to integrate the range of place meanings into a "Web of River Meanings," to show how interpretive approaches may be incorporated into science-based planning processes. Through this process, land managers had the opportunity to improve community cohesion and cooperation during negotiation of potentially contentious management issues. The concept of place meaning was also explored by Brandenburg and Carroll (1995) in terms of "landscape meaning," using "analytical induction" to identify distinctions in how stakeholders experienced a national forest in Washington State, as shown by values, beliefs, and shared wisdom symbolized by trees and other natural features of the area. They discovered that commonalities in place meaning emerged that were unexpected from traditional responses for various "group-based belief systems." Both of these studies suggest how *Sense of Place*, as described by place meaning, allows the possibility for land use planners to acknowledge the power of placed-based values in appealing to diverse stakeholders' support for action alternatives, in lieu of "reductionist" views of the landscape.

Individual interpretations of place and the meanings that are ascribed to place are obviously contingent on conditions that operate differently within specific regional contexts. Consequently, understanding these differences should facilitate communication among various constituencies (e.g., recreational users, wilderness preservation interests, agency personnel, and other stakeholders) in the process of developing ecosystem management decisions (Williams and Patterson 1996). Differences in how place meanings are translated into attitudes and behavior reflect not only personal interpretation, but also physical characteristics of a setting, activities and experiences in a setting, length of time one has lived in an area, and other social phenomena and processes (Davenport and Anderson 2005, Jones, Fly, and Cordell1999, Jones et al. 2003, Williams and Patterson 1996). These attitudes toward and preferences for natural resource management alternatives have often been hypothesized to fall along an ''anthropocentric/biocentric continuum'' (Racevskis and Lupi 2006). An anthropocentric value orientation takes a human-centered view of the non-human world, valuing natural resources in utilitarian terms of the products and services they provide for humans (McFarlane and Hunt 2006, Vaske et al. 2001). The "extractive-commodity" theory assumes that these utilitarian values are held more strongly by rural residents because they are more dependent on the direct extraction of natural resources (Jones et al.1999). A biocentric value orientation, on the other hand, is a nature-centered perspective that "… does not deny that human desires and human values are important, but it places them in a larger, natural or ecological context" (Steel, List, and Shindler 1994:139). Thus, the biocentric view is consistent with support for environmental values, which has been often associated with urban residents (Van Liere and Dunlap 1981, Tarrant and Cordell 1997). However, many more recent findings in the social forestry literature have concluded that this relationship between place and value orientations is less distinct. For example, in their comparison of urban and rural residents of Michigan's Central Upper Peninsula, Racevskis and Lupi (2006) found that attitudes expressed by participants in their focus group study did not fall neatly on the anthropocentric–biocentric continuum. Although rural residents valued the forest for utilitarian purposes, these were more oriented toward concern for community well-being (e.g., support of local tourism) than urban residents, who expressed anthropocentric views of the forest as a resource for their personal recreational use. Rural residents also revealed a biocentric stance with regard to forest preservation as a means to support wildlife habitat. These findings suggest the complex nature of human relationships with the landscape due to contextual social and economic forces that interact with normative value orientations. These relationships, in turn, potentially influence attitudes about and support for sustainable forest management practices (McFarlane and Hunt 2006).

The treatment of peoples' conflicting (and shared) viewpoints in NRM policy brings into focus the politics of place, and how variation in *Sense of Place* may be connected to larger political struggles and cultural history (Yung, Freimund, and Belsky 2003, Nash et al. 2010). Socio-political approaches to NRM acknowledge this political dimension of landscape meanings, and how groups of people construct competing senses of place in order to invoke power and authority over a place (Nash, Lewis, and Griffin 2010). The conflict may be characterized by reframing a powerful cultural or social symbol of a particular place as essential for all citizens, such as in the cases where the coho salmon and the spotted owl were used to symbolize the importance of preserving wildlife habitats in coastal Pacific Northwest watersheds and Oregon old growth forests (Yaffee 1994, Yung et al. 2003, Steel et al. 1994, Rickenbach and Reed 2002). Since any physical place has the potential to embody multiple cultural definitions of those who encounter that place, the processes of negotiation cause these shared, "reified" symbols and meanings to emerge as socially-constructed artifacts defining "social and natural phenomena" for that particular landscape (Greider and Garkovich 1994). In this way, the concept of ecosystem protection is less abstract and more about the function of particular places, such as the Columbia River Basin or old growth forests in the Pacific Northwest as habitats for the coho salmon and spotted owls; locations that people become attached to and/or concerned about give them some sense of the value of ecosystem management. Although the conflict may be initially framed in terms of preserving the habitat of owls or fish, often the NRM negotiations hinge on the power struggle among a variety of stakeholders – for example, loggers, rural businesses, international logging companies, and environmentalists – to shape the definition of the situation and preferred social actions that result from divergent place meanings (Yung et al. 2003, Greider and Garkovich 1994). However, by facing these place-based conflicts, stakeholders may potentially promote a healthy competition of ideas as a mechanism to stimulate policy change and learning, setting the stage for diverse outcomes and future collaborative relationships (Bidwell and Ryan 2006).

Finally, there is concern that geographical distinctiveness and meaning are in the process of disappearing altogether, with the urban–wildland interface stretching particularly far from urban centers (i.e., "sprawl"), combined with the increasing homogenization of the landscape by rampant commodification of natural settings (Sopher 1979, Gilbert 2009). This highlights the urgency in addressing sustainable NRM practices on a much larger scale, with the increased fragmentation of natural habitat and accompanying threat to biodiversity (Colburn 2006). Bridging the gap between local and bioregional approaches in NRM continues to be a moving target, because of the continuing redefinition of spatial scales as arbitrated by political power structures (Harvey 1996). The fluid nature of a "region," reflexively linked to human agency from below and structural relations from above, is similar to a "bioregion" in that it is a semi-determining ecological space both responding to and conditioning a local "collective social or cultural consciousness in which are embedded a set of normative values" (McTaggart 1993:308). Thus, bioregional theory holds forth that human activities and decision-making can be directed in ways that are closely aligned with place-based criteria of ecological sustainability and local values (Feagan 2007).

Despite the modernist sociopolitical discourse that emphasizes the vulnerability of geographical identification, notions of place and localism appear to be re-emerging as able to contribute to and set the context for transformative place-based politics. In the NRM arena, effective management of project development and community responses to environmental change can benefit not only from the contribution of natural science to help practitioners determine ecosystem interactions, but also from understanding how social-ecological factors impact acceptance of proposed land use alternatives. The sociological framework that defines landscapes emphasizes the multiple meanings of the environment to a community, and how these meanings are extensions of how people define themselves.

Urban Forest Management

The sustainable land use planning component of natural resource planning that addresses management of woodlands around urban and suburban areas has given rise to a distinct research and management area known as "urban forestry." Urban forestry is defined as "the art, science and technology of managing trees and forest resources in and around urban community ecosystems for the physiological, sociological, economic and aesthetic benefits trees provide to society" (Helms 1998:193). The "urban forest," defined as trees in populated areas, such as cities, golf courses, urban parks, and subdivisions (Konijnendijk 2000, Wu 2008, Tyrväinen, Silvennoinen, and Kolehmainen 2003, Vesely 2007) is a crucial component of the urban ecosystem due to its role in mitigating the negative effects of urban development. The urban forest forms a nested spatial hierarchy: individual trees, tree corridors (e.g., street trees), trees in neighborhoods and commercial areas, patches of trees in parks or undeveloped lots, and the entire urban forest in and around the city (Wu 2008).

Given the expanding ecological footprint of urban areas, the urban forest has become an increasingly important component of bioregional ecological health. However, urban forests and their benefits are unevenly distributed across the landscape. Based on American Forests' Urban Ecosystem Analyses conducted over the past six years in ten cities, an estimated 634,407,719 trees have been lost from metropolitan areas across the U.S. as the result of urban and suburban development (American Forests 2011). This is often due to the failure of municipalities to integrate trees and other elements of the green infrastructure into their day-to-day planning and decision-making processes (American Forests 2002). The regional context in which contiguous urban forests reside has also been impacted by fragmentation due to sprawl as well as other social and ecological effects (Webb, Bengston, and Fann 2008). This uneven distribution of urban forests and their benefits ultimately impacts broader ecosystem protection goals (e.g., maintaining biodiversity and wildlife corridors), highlighting the need to gain a better understanding of the hierarchical linkage among “tree clusters” and the socio-spatial dynamics that are associated with tree canopy health at different scales (Wu 2008).

In response to the increased awareness of this significant public resource, a large part of urban forestry research is devoted to assessing change in tree cover through econometric modeling, photo-simulations, imaging software, aerial photography, and satellite imagery (Creps et al. 2001, Nasser 2005, Heynen 2006, Dwyer et al. 2000, Nowak et al. 1996, Grove et al. 2006, Tyson et al. 2004, Jenerette et al. 2007, Wall, Straka, and Miller 2006, White et al. 2009, Poudyal 2008, McPherson and Rowntree 1993, Kuo et al. 1998). Other research is devoted to examination of biophysical attributes of urban trees, information that proves valuable to not only to community residents, but also business leaders, public health agencies, educators, and governmental decision-makers (Sanders 1986, Schmid 1975, Heisler 1986). Most research is based on case studies that estimate the value of the urban forest within a local context and to help urban foresters implement effective tree management strategies. These studies have served to identify a wide range of benefits and significant values associated with urban forests and trees, and as newer research emerges, interest in management of urban forests has grown (Barro et al. 1997, Dwyer, Schroeder, and Gobster 1991, Dwyer et al. 1992, Heynen and Lindsey 2003, Maller et al. 2006, McPherson 2007, Pauleit 2003, Treiman 2006, U.S. Department of Agriculture 2004, Wolf 2005, Wolf 2007).

Social scientists have studied how having trees and common green spaces in urban and suburban environments serve to restore the sense of social connectivity, in addition to contributing to aesthetics, public health and well-being, property values, and community stability (Tyrväinen et al. 2003, Wolf 2004, Youngentob and Hostetler 2005). The high value that Americans have historically placed on trees and open spaces in cities is shown in an 1821 report issued about the selection and design of a permanent capital of Mississippi:

> And even in a small town there would be a comfort, convenience, and greater security against fire, as well as a fairer promise of health, all combined, by having every other square unoccupied by anything except the native trees of the forest, or artificial groves. (Zube 1973:49)

The rapid urbanization of American cities in the late 19th century was a concern to many as encouraging intellectual separation of humanity and nature (Rees 1997). By the end of the 19th century, social "reformers" were just beginning to understand the relationship between developing parks in urban areas and "[engendering] a better society" (Young 1995:536). At this time, parks and trees were not necessarily seen as a way to allow urban dwellers to experience nature, but more of a means of providing mechanisms of acculturation and control for newly-arrived immigrants and their children (e.g., areas to encourage "structured play" and thus serve as a deterrent for youth crime) (Pincetl and Gearin 2005). Other prominent public intellectuals were interested in exploring the synergy between ecological and social systems, including American landscape architect Fredrick Law Olmsted, designer of 17 major U.S. urban parks and a visionary in seeing the value of including green space and trees as a fundamental part of metropolitan infrastructure (Young 2009). To Olmsted, unity between nature and urban dwellers was not only physical, but also spiritual: "Gradually and silently the charm comes over us; the beauty has entered our souls; we know not exactly when or how, but going away we remember it with a tender, subdued, filial-like joy" (Beveridge and Schuyler 1983 cited in Young 2009:320). The conscious inclusion of trees in urban designs for American cities such as Chicago, San Francisco, and Minneapolis was also inspired by Paris's urban forest and its broad, tree-lined boulevards as well as by the English romantic landscape movement (Zube 1973). The belief in green cover by early park proponents as a promoter of social cohesion has been corroborated by more recent research that links trees to the presence of stronger ties among neighbors, more adult supervision of children in outdoor areas, more use of the neighborhood common areas, and fewer property and violent crime (Kuo et al. 1998, Kuo and Sullivan 2001, Kuo 2003).

There is a long association with the presence of trees and wooded lots with upper- and middle-class residential values in the United States. The "natural landscape" popularized by the writings of Thoreau in the 19th century served to awaken new aesthetic and spiritual forest values that contrasted with industrialized cities lacking in qualities of nature (Zube 1973, Bengston, Webb, and Fann 2004). As larger portions of the urban forest became privatized during the 20th century through the proliferation of suburbs, the presence of a healthy tree canopy around one's home became associated with higher social status Zube 1973). Indeed, most prestigious urban residential areas today are in wooded sections; this relationship has been attributed to expanded leisure resources available to higher-income homeowners to cultivate private residential trees (Zhu and Zhang 2008). Big trees may also be a feature of expensive, aesthetically-pleasing real estate to which wealthier home-buyers are attracted (Cho, Poudyal, and Roberts 2008, Conway and Hackworth 2007). Moreover, the presence of *public* tree canopy and green areas has also become increasingly linked to higher real estate values. Unevenly distributed public amenities such as park space and trees has been explored in environmental justice research as indicative of neighborhood-scale disinvestment by municipalities through the deprivation of marginalized low-income areas to the positive externalities provided by public urban trees (Zhang et al. 2008, Heynen, Perkins, and Roy 2006, Heynen 2006, Jensen et al. 2004).

Trees and forests play a significant role in the urban environment and have many important meanings for urban residents. The value that people place on trees is especially evident with respect to big trees. There has always been a public fascination with large trees, especially the largest specimens of trees that reach a mature height of greater than 40 or 50 feet (i.e., Champion Trees) (Barro et al. 1997, Dwyer et al. 1991). Moreover, the ability of big street trees to create a ceiling of branches and leaves over all or part of a street impacts the scale of changing shadows cast by the trees, sunlight filtration, and other human-scale considerations that provide a changing visual environment (Zube 1973, Jones and Cloke 2002). In their qualitative study of Denmark residents' perceptions of the importance of the urban forest, Hansen-Moller and Oustrup (2004) found that the scale of urban trees was one of the main conditions of an “ideal” urban forest, through its volume, height, and ability to envelop a person, thus creating a barrier from the outside world.

Although quite striking in an urban environment, large trees present a continuing dilemma for the field of urban forestry due to the stresses that urban trees undergo from automobile exhaust, constraining hardscape and building foundations, and physical damage (Pickett et al. 2008). The constraints that the typical urban environment places on trees limits the average lifespan of a city tree to only 32 years – 13 years if planted in a downtown area – which is far short of the 150-year average life span of trees in rural settings (Herwitz 2001). Moreover, removal of trees because of disease and/or safety hazards often causes grief or anger to those who live in their vicinity. Ley (1995) describes the loss of two Sequoias in a suburb of Vancouver:

> The trees are an extension of the self, the social self, the confirmation of an identity shared with like-minded others. And so it is a collective neighborhood loss that is announced in this arboreal obituary. (p. 203)

However, public awareness of big trees can boost public support for urban forestry by enhancing public appreciation of trees, informing people about the important role trees play in urban settings, and providing motivation for citizens to maintain and care for all urban trees (Barro et al. 1997).

In their book “Tree Cultures: The Place of Trees and Trees in their Place,” Jones and Cloke (2002) discuss the importance of reaching an understanding of the broad cultural constructions that trees import to *Sense of Place*. As prominent “things,” arranged in distinctive formations, trees command a symbolic and material presence that informs how places and landscapes are imagined. This link that humans have to trees has been theorized by Kellert and Wilson (1993) to be a genetically-based emotional need to be close to trees and other greenery. According to their the “Biophilia Hypothesis,” millions of years of human survival and evolution depended on our ability to cope with the natural world; learning what was safe and dangerous involved the imprinting of strong positive and negative emotional reactions to various natural stimuli. Although 21st century American society is no longer as dependent on nature for day-to-day survival, Kellert and Wilson suggest that closeness to the natural world is still critical for psychological well-being. The complex symbolic and emotional ties that humans have with trees have important implications for the importance of sound urban forest management practices that impact not only quality of life on an ecological level, but on the human and cultural level.

In recognition of this, many municipalities throughout the U.S. employ community-level tree ordinances to empower planning officials to regulate the planting, maintenance, and preservation of trees. The development of tree ordinances emerged largely as a response to the Dutch Elm Disease that plagued cities from the 1930s to 1960s, and grew in response to urban development, loss of urban tree canopy, and rising public concern for the environment (Wolf 2003). The 1980s saw the beginning of the second generation of ordinances with higher standards and specific foci, as communities sought to create more environmentally pleasing harmony between new development and existing infrastructure. These new ordinances, legislated by local governments, may include specific provisions such as the diameter of tree and percentage of trees to be protected during construction activities (Xiao 1995, Jones and Davis 2011). The implementation of these tree ordinances is greatly aided by a significant effort by community tree advocates to conduct public outreach and education aimed at increasing environmental concern for urban trees, such as through National Arbor Day celebrations and the USDA Urban and Community Forestry Program (Dwyer et al. 2000, Hunter and Rinner 2004, Norton and Hannon 1997, Wall et al. 2006).

Several descriptive studies have examined characteristics of existing tree ordinances in different areas of the U.S. in order to relate their effectiveness with socio-demographic variables. Allen (1997) attempted to relate socio-demographic characteristics and tree ordinance “rigor” in 93 Alabama communities (as defined by the number of items the ordinance addressed from a list of 55 potential ordinance provisions), and was unable to find a relationship. However, he did find that communities in the Gulf Coast and Southeast regions had employed tree ordinances for the longest period of time. Also, he surveyed Alabama mayors and developers to compare their awareness and knowledge regarding tree ordinances, the value of trees, factors that affect decisions to save trees, and the effect of certain construction site activities on trees. He discovered that both groups agreed that trees provide aesthetic, environmental and social benefits; however, each group was less aware of the impact of trees on water quality than on air or noise pollution. Neither group expressed knowledge of the impact of trees in the urban environment on the local economy. Dickerson, Groninger and Mangun (2001) examined tree ordinances in Illinois and found that the size of a community, level of education, and income were correlated positively with stronger tree ordinances. In a survey of 421 randomly selected Missouri residents, Treiman and Gartner (2005) found that women and younger people tend to favor stronger regulation of tree protection. Lack of municipal funding and insufficient knowledge about urban forestry were found to inhibit the enactment of tree protection legislation in towns throughout Pennsylvania (Elmendorf et al. 2003). Organized intervention by state-funded urban foresters was found to improve the extent of urban forest management in communities throughout Oregon (Ries, Reed, and Kress 2007).

With the shift away from command and control, top-down resource management approaches of urban ecosystems, social and political aspects of management initiatives—including citizen perspectives— are increasingly important for participatory approaches that address the diffuse nature of urban tree protection and management. As in rural/urban interface issues that have contributed to a blurring of the lines between traditional forestry and urban forestry, regional collaborative planning that transcends jurisdictional boundaries is needed to provide solutions to the problems created by societal demands (Ricard and McDonough 2007, McPherson 2006, Bratkovich 2010, Scarlett 2010). This can be accomplished, for example, through watersheds, which provide a definable organizing structure for understanding a region's ecosystem along an urban-to-rural gradient (McPherson 2006). In Tennessee, the Tennessee Urban Forest Council (TUFC), a non-profit funded partly by the U.S. Forest Service, coordinates regular "town hall meetings" among local Tree Boards, urban foresters, and municipal officials, to discuss strategies to maintain the health of the local tree canopy and raise public awareness of urban trees. The Tree Board Breakfast held at the annual conference of TUFC also serves as forum for information exchange among tree advocates from communities all across Tennessee (Jones and Davis 2011).

Ostrom and Nagendra (2006) believe collaborative planning to cultivate a culture of stewardship is essential for developing a conservation ethic among individual community members. They found that if landowners play a role in making local rules for management of natural resources, they were more willing to monitor surrounding land uses to ensure others were also conforming to community standards. This leads to the idea that public participation during the policy-making process leads to a greater willingness of private landowners to become less "place-centered" with regard to protection of their immediate surroundings, in order to extend their environmental concern to a wider area that may include public trees as well as the urban forest in adjoining communities. Norton and Hannon (1997) theorize that acknowledging "particularities of local cultural adaptations" of local ecosystems is key to integrating local sentiments about environmental protection into larger scale systems. As in NRM, empowering stakeholders to take responsibility for environmental management of the local urban forest builds a positive

Sense of Place, setting the stage for mobilization of broader public support for protectiveness of "space *around* their place." It is hoped that the social theorizing on which this dissertation focuses may serve as the starting point for a model for both ecological functions and social functions across multiple scales.

Theoretical Approaches for Understanding Public Concern for the Environment and Urban Forestry

Attitude-behavior environmental research has shown evidence of a positive relationship between ecological attitudes and environmental protective actions (or support for protection of the environment). However, such findings are often unsuccessful in establishing causal relationships, especially when examining "environmental concern" and behavior that one would presume be related to specific concerns (Stern and Oskamp 1987). Stern and Oskamp identify several factors that confound the study of attitudes' influence on behavior, including the fact that attitudes and beliefs are embedded in personal values as well as unique social and physical contexts. These contexts may mediate (and moderate) behavior outcomes in unpredictable ways and include things like physical structures, social institutions, economic forces, access to information, and behavioral intentions (Guagnano, Stern, and Dietz 1995). In an attempt to clarify the relationship of antecedent independent variables contributing to environmental behavior, a "cognitive hierarchy" framework consisting of basic values, general beliefs, specific attitudes, and behavior has been suggested as a starting point (Stern, Dietz, and Guagnano 1995, Dietz, Stern, and Guagnano 1998).This will be discussed later in this chapter.

When attitudes and behaviors are measured at the same level of specificity or generality, much greater correspondence has been found (Ajzen and Fishbein 1980, Manfredo et al. 2004). For example, place-protective behavior due to place-specific risk of (or already occurring) environmental problems (e.g., "not in my backyard," or NIMBYism) may have an environmental stance associated with it, but may not be related to how this same population feels about broader environmental issues which may impact people in another region (Norton and Hannon 1997). This unique "place-based" relationship between attitudes and behavior has given rise to the merging of place theory and attitude theory to include *Sense of Place* as a form of attitude. Thus, *Sense of Place* was incorporated in the hypothesized model in order to improve attitude-behavior modeling by including an external variable, urban tree canopy density, as an easily-measured integrative factor that tracks social variables to represent place-based identities based on shared meanings of tree places. As a “context” that represented external conditions, it was hoped that it would clarify the linkage among the social factors in the prediction of *Support*.

For the purposes of developing a theoretical framework for the current research, foundations of attitude theory are first presented below, as they relate to work conceptualizing environmental concern. This subsection concludes with a review of empirical literature that draws from attitude theory to predict concern about urban trees. Next, I discuss how environmental sociology incorporates the use of place-based contexts in theorizing. This section concludes with an overview of literature in which GIS is used as a tool in place-based social research.

Values and Environmental Concern

Values are commonly defined as general and enduring beliefs that provide standards or normative prescriptions by which people evaluate themselves, issues, and events (Rokeach 1973, Schwartz 1992). As Dunlap and others (2000) have noted, the term has been used interchangeably with other concepts such as environmental concern, ecological worldview, and environmental attitudes. As such, reviewing the literature in this area involves reference to a number of alternative bodies of research, which are covered below.

Variations in value structures across groups are often studied by social scientists, in order to understand significant differences in the way these groups organize their understanding of and actions within the world. This may occur on a macro level, through the examination of how social and political structures of societies result in different value priorities (Schwartz 1992). On a micro level, individual experience, knowledge, beliefs, attitudes, and concern for the environment have all been linked to support for environmental protection (Dunlap and Jones 2002, Stern et al. 1995). Variations in value structures may further be linked to a micro/macro community context that refers to different levels of the physical environment, from the home, to the neighborhood, to the town and surrounding bioregion (Blanco et al. 2009). In short, attitude theory studies generally have an individual-level focus while policy-relevant studies often have a structural-level focus (Dunlap and Jones 2002). Drawing from Stern, Dietz and Guagnano’s (1995) modified theoretical model of environmental concern, Funk (2000) realized the opportunity for the convergence of these two approaches when she theorized that values, beliefs, and knowledge are linked with awareness of the need for more environmentally sustainable policies to counteract global environmental problems such as climate change. This awareness, in turn, leads to behavior that includes human response to policies and planning decisions, including support for various environmental policies such as community tree ordinances (Stern et al. 1995, Funk 2000). Similarly, how we view urban trees and individual and collective actions to utilize, maintain and protect them are influenced by social values and structures, cultural and symbolic meanings about ourselves, our place in the world, the environment, and nature.

Drawing from attitude theory, “environmental concern” is often conceptualized as “the degree to which people are aware of problems regarding the environment and support efforts to solve them and/or indicate a willingness to contribute personally to their solution” (Dunlap and Jones 2002:485). Concerns are rooted in values but are conceptually distinct from them in that “concern” reflects both a sense that something is important and a belief that it may be at risk (Dietz et al. 2005). In the area of environmental sociology, the important role of public concern for the environment is emphasized in how it is connected to individual and collective actions to improve environmental quality (Dunlap and Jones 2002, Routhe et al. 2005). Studies of environmental concern also suggest that factors others than attitudes influence support for collective actions to improve the environment while attitude theory suggests that specific attitudes about a collective action are related to more general values, beliefs, preferences and concerns (Dietz et al. 2005, Dunlap and Jones 2002, Routhe et al. 2005, Rival 1998, Barro et al. 1997, Dwyer et al. 1991, Carreiro and Zipperer 2008).

Modern environmentalism is seen by many to have been inaugurated by the publication of Rachel Carson’s *Silent Spring* (Carson 1962). Serialized in The New Yorker, it triggered public discussion for the first time among representatives of the chemical industry, scientific academies, conservation groups, and various government agencies about environmental toxicity and more generally on the chemical industry's accountability for the ecological dangers of synthetic chemical production. Historians have suggested that *Silent Spring* was to environmentalism what *Uncle Tom’s Cabin* was to abolitionism: a spark for a new consciousness about the environment, ultimately resulting in the banning of DDT use in United States (Wang 1997). This new evidence of environmental concern led some sociologists, led by Catton and Dunlap (1978) to begin to examine how environmentalism represented potentially a fundamental shift in how people understood the world. Most notably, Catton and Dunlap proposed a new, less anthropocentric, sociological worldview they called the “new environmental paradigm” (NEP). As an environmental attitude scale, the NEP measures environmental concern and is comprised of multiple beliefs regarding limits to growth, balance of nature, and a biocentric philosophy. Since the NEP was conceptualized, many environmental sociologists have assessed the extent to which different groups subscribe to the NEP, resulting in documentation of its usefulness as both a dependent and an intervening variable in attitude-belief-behavior studies (Dunlap and Jones 2002). Such studies provide insight into the basic values and beliefs on which more specific environmental attitudes and actions are based, and suggest that changes in values offer a bridge to more sustainable behavior and more effective environmental policy. This viewpoint assumes that values influence individual and collective decisions and that environmental values influence decisions to be more protective of the biophysical environment (Dietz et al. 2005).

The term "environmental values" is used to represent underlying orientations held by individuals toward the physical (Barr 2007). According to Homer and Kahl (1988), "values are similar to attitudes in that both are adaptation abstractions that emerge continuously from the assimilation, accommodation, organization, and integration of environmental information in order to promote interchanges with the environment favorable to the preservation of optimal functioning" (p. 638). Values differ from attitudes in that attitudes are positive or negative evaluations of something quite specific. For example, one may value "wilderness," and oppose a proposal for oil development in a wildlife refuge. The former is more abstract and evaluative; the latter, as an attitude, is more concrete as a specific evaluation (Dietz et al. 2005, Rokeach 1973).[4] Value orientations may also affect beliefs about "attitude objects" (e.g., environmental conditions, or other things an individual values) and thus have consequences for that individual's attitudes and behavior. Consequently, values may cause an individual to be selective in the information he/she seeks out, thus further reinforcing beliefs and behavior (Stern and Dietz 1994).

Attitude Theory as a Basis for Studies in Environmental Concern

Attitude-behavior theory offers a means for understanding why people may express environmental concern, in addition to why they may support or oppose particular management proposals that impact the environment. A theoretical formulation that links environmental concern to environmentally relevant action is Schwartz's (1970) theory of the activation of personal normative beliefs. His "norm-activation theory" has important practical implications for

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[4] However, "value" has been used interchangeably with other concepts such as environmental concern, ecological worldview, and environmental attitudes (Dunlap et al. 2000).

understanding how environmentally relevant behavior comes about and how it can lead to political action. For example, environmental concern (i.e., a "moral norm") may be activated by publicly available information about a situation that incites political action on the part of an individual or community. In other words, "attitude formation" would occur as a result of knowledge, which subsequently leads to social action; this could be public support for a policy.

In addition to norm-activation theory, other social-psychological theories have postulated how attitudes and normative beliefs mediate the relationships between more general values and behavior (Schwartz 1992, Stern et al. 1999). Many studies concerned with the prediction of behavior from attitudinal variables are based on Theory of Planned Behavior (TPB) or the Theory of Reasoned Action (TRA) (Ajzen 1991, Ajzen and Fishbein 1980). TRA posits that an individual's behavior that is under his/her volitional control is determined by behavioral intention; behavioral intention in turn is jointly determined by attitude toward the behavior and subjective norms[5] (Ajzen and Fishbein 1980). However, behaviors are not always under volitional control. To eliminate this limitation, TRA was extended to become TPB (Ajzen 1985). According to TPB, people act in accordance with their intentions and perceptions of control over the behavior, while intentions in turn are influenced by attitudes toward the behavior, subjective norms, and perceptions of behavioral control. Other theorists have built on TPB to consider contextual (Guagnano et al. 1995), personal capability (Stern et al. 1999), or habitual (Dahlstrand and Biel 1997) influences on environmental behavior. As the knowledge base in this area of theorizing has grown, researchers are generally in agreement that specific belief, attitudinal, or normative variables are more likely to predict behaviors than more general measures like values (Ajzen and Fishbein 1980). Substantial interest remains, however, in improving models that explain the conditions under which fundamental values affect environmental behavior or evaluations (Stern 2000).

Put simply, attitudes can be defined as positive or negative judgments about an object or phenomenon (Dietz et al. 2005). Yet environmental attitudes are complex and multidimensional, conceptualized by scholars as a tripartite of interrelated realms serving as domains for attitude expression or response to "attitude objects": affective (feelings and emotions), cognitive

[5] A subjective norm is a person's perceptions of significant others' preferences about whether one should engage in a behavior (Ajzen and Fishbein 1980).

(knowledge and beliefs), and conative (intentions) components (Dunlap and Jones 2002, Fishbein and Ajzen 1975, Routhe et al. 2005). The *affective* value of attitude has been found to accurately gauge individuals' tendency to behave favorably or unfavorably to a class of attitude objects, such as preferences for certain landscapes which may contain a varying amount of trees (Balram and Dragićević 2005, Kaltenborn and Bjerke 2002, Tyrväinen, Mäkinen, and Schipperijn 2007). The *cognitive* component of the attitude construct consists of the knowledge facet of an attitude, which may include personal thoughts, beliefs, and ideas (Cottrell 2003). Finally, the *conative* component "refers to the action or behavioral tendencies of an individual regarding an object" (McGuire 1969 in Cottrell 2003:350).

The socioeconomic profile of a particular community, state, or region may also influence environmental attitudes and support for tree protection (Heynen et al. 2006, Jensen et al. 2004, Wolf 2004). Support for tree protection may be influenced by an individual's position in the social structure, and variables such as age, level of education, area and length of residence, gender, income and political and environmental affiliation have been found to be related to public support for trees and the environment (Allen 1997, Dickerson et al. 2001, Dunlap and Jones 2002, Jones and Dunlap 1992, Jones et al. 1999 and 2003, Routhe et al. 2005, Treiman and Gartner 2005, Zhang et al. 2007). Demographics are not tied directly into environmental behavior, but are shown in the literature to be mediated by the components of environmental concern (Cottrell 2003, Brand 1997). For example, Van Liere and Dunlap (1981) found that females, and urban residents were more likely to support pro-environmental behavior, and Klineberg et al. (1998) reported that younger, more-educated, female and liberal respondents expressed the highest level of environmental concern in general. Jorgensen and Stedman (2006) found that the length of residence was strongly related to pro-environmental attitudes. However, Allen (1997) found no relationship between socio-demographic variables and tree ordinance "rigor" (as defined by the number of items the ordinance addressed from a list of 55 potential ordinance provisions). In summary, studies strongly suggest that socio-demographic and social structural variables do not directly relate to variation in public support for the environment, but indirectly influence it instead through mediating variables such as experience, knowledge, attitudes, and beliefs (Cottrell 2003, Jones and Dunlap 1992, Dunlap and Jones 2002, Lohr and Pearson-Mims 2005).

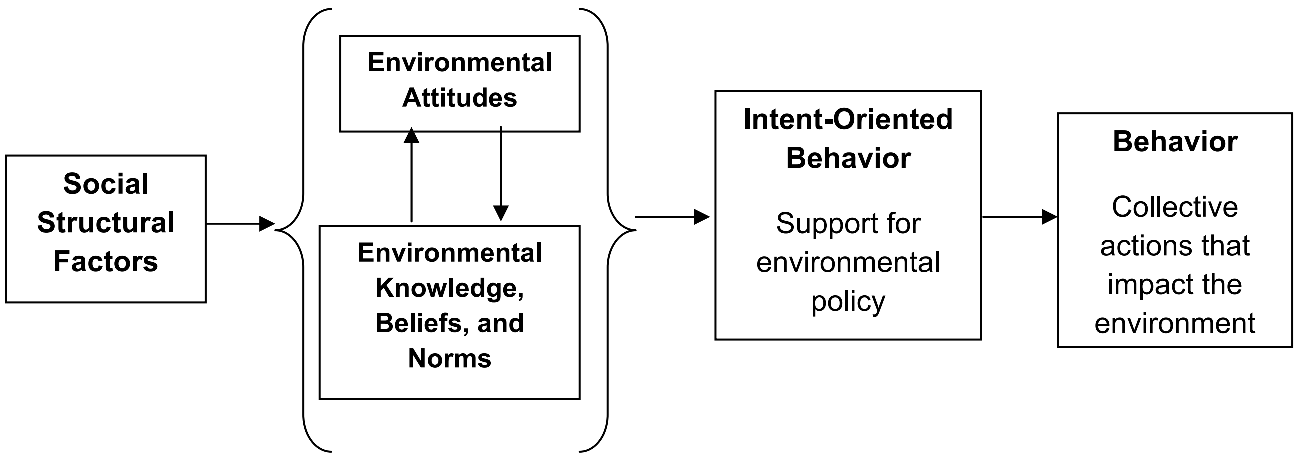

Figure 2.1. Attitudinal theory as it relates to this study, combining the ideas of Dunlap and Jones (2002), Routhe and others (2005), Stern and Dietz (1994), and Stern and others (1995).

Within a given situation, influence of values should theoretically flow from abstract values to midrange attitudes to specific behaviors, as implied by Figure 2.1. This sequence is often referred to a "cognitive hierarchy" (McFarlane and Boxall 2003, Stern et al. 1995, Vaske et al. 2001, Whitaker et al. 2006, Larson 2010, Fischer 2010). Cognitions, and therefore values, guide individuals in their decisions about which situations to enter and what they do in those situations. A central concept in modeling behavior as an outcome of values, beliefs and attitudes is the need for compatibility or correspondence with the behavior that is to be "predicted." When correspondence between variables is similar (in terms of target, action, and context), statistical relationships between variables are predicted to be stronger (Fishbein and Ajzen 1975). But to gain insights into problem-specific attitudes, flexibility is essential for tailoring an attitudinal framework to particular issues. The work presented in this dissertation addresses resource management initiatives within a specific context (protection of the urban forest), and the attitudinal measures discussed in Chapter 4 have been developed from domain-specific measures from past work. Although this study joins a multitude of other attitudinal studies (estimated by Dunlap and Jones to number over 1,000) for which goals, actors, and strategies (or objects) vary considerably, it is hoped that the relative strength of demonstrated relationships can help assess the merits of including variables and their mediating effects in larger models.

The extraordinary number of environmental attitudinal measures that exist (Dunlap and Jones 2002) was described by Stern (1992) as an ‘‘anarchy of measurement’’ (p. 279). As a latent construct, attitudes cannot be observed directly. Thus, rather than being measured directly, attitudes must be inferred from overt responses to questions crafted from psychometric inventories and scales related to particular topics of interest (Himmelfarb 1993). Examples of measurement instruments that have been developed in empirical studies of values and attitudes include Catton and Dunlap’s NEP (1978), the Rokeach Value System (Rokeach 1973) and the Schwartz Value Survey (Dietz, Fitzgerald, and Shworn 2005), which provide the foundation for higher order attitudes and behaviors. Schwartz and Bilsky (1987) built on Rokeach’s earlier model to develop a list of 56 survey items that are rated along a 9-point scale for importance as “guiding principles” in one’s life. In summary, direct self-report techniques, such as scales and inventories, are the most widely used methods for measuring environmental attitudes. There are several scales measuring environmental attitudes but with no accepted “gold standard” measure in the literature (Milfont and Duckitt 2010). Moreover, assessment of construct validity of attitude measuring instruments is difficult because it depends on how measures interrelate in ways that are theoretically specified (Dunlap et al. 2000).

The latent structure of constructs that make up attitude-behavior frameworks lends itself to confirmatory factor analysis (CFA), which focuses solely on how, and the extent to which, the underlying observed variables are linked to specific latent factors. Therefore, it is important that the researcher operationally defines the latent variable of interest in terms of attitudes and behavior believed to represent it. CFA allows a more sophisticated examination of the dimensionality of environmental concern constructs, and also allows the analyst to take into account both sources of random error (in the psychometric sense) and nonrandom error (error uniqueness, a term used to describe error variance arising from some characteristic that is considered to be specific to a particular indicator variable) (Byrne 2010). As I will discuss in Chapter 4, CFA is employed to test the validity of indicator variables measured by the current study’s survey instrument that provided the data used in this dissertation research.

The relative strength of relationships among beliefs, attitudes, and behavior can help assess the merits of including variables, or tests for mediation, in larger models. Lived experiences, such as experience with environmental problems, are thought to influence environmental beliefs about the pollution risk, which in turn lead to support for policies that would mitigate this risk (Zahran et al. 2006). Patterns of basic beliefs are thought to mediate the relationship between awareness of environmental issues (knowledge) and relatively concrete attitudes (Larson 2010, Nordlund and Garvill 2002). Conative attitudes (conceptualized as one of the “tripartite” attitudes), are in turn thought to be predictive of potential voting behaviors or civic actions, such as expressed support or opposition for environmental management goals or governance strategies (Larson 2010). In order to test these predictive relationships in a single model, structural equation modeling (SEM) was employed as an analytical method in the current research because of its ability to test relationships simultaneously and its capacity to incorporate multiple measures of underlying constructs. SEM combines confirmatory factor analysis with path analysis, thus allowing the modeling of the latent constructs described above and their direct and indirect relationships. Using SEM, it is therefore possible to give structure to an explanatory model, and unlike models employing conventional regression analysis, structures can be made explicit and testable. Attitudinal measures from previous research are employed in this dissertation research to facilitate direct comparisons across studies, which are discussed below.

Application of Attitude Theory to Urban Forestry

The theoretical foundation of this study is derived in part from attitude theory, which emphasizes the important role public concern for the environment (i.e., “environmental concern”) plays in understanding and predicting individual and collective actions to improve environmental quality (Dunlap and Jones 2002, Routhe et al. 2005). Although there is a large and expanding body of research that examines environmental concern (Dunlap and Jones 2002), there are a limited number of in-depth peer-reviewed studies that deal directly with public concern for the maintenance and protection of urban trees in the United States (Jones and Davis 2011). This section reviews studies on attitudes, concern, beliefs, and support for the environment with regard to the urban forest (Jones and Davis 2011).

How we view urban trees and individual and collective actions to utilize, maintain, and protect them are influenced by social values and structures, cultural and symbolic meanings about ourselves, our place in the world, the environment, and nature (Rival 1998, Barro et al.1997, Dwyer et al.1991, Carreiro and Zipperer 2008). DeKay and O’Brien (2001) suggest that direct experience with the natural world is necessary to nurture an ecologically literate society and has the competence to perform long-term planning to preserve biodiversity and nature in the face of short-term economic gain. Influences on public support for urban tree protection policy shown in the literature include exposure to traditions of gardening, urban planning, and landscape preferences. Summit and Sommer (1998) posit that it takes direct action to raise community awareness of the benefits and value of urban trees. For example, tree-planting programs show community residents how easy it is to plant trees, demonstrates their benefits, creates opportunity for people to work together, and makes environmental values and behavior more appealing. Thus, it appears that knowledge and direct experience with trees help to nurture values supporting environmental protection and sustainability (Chiesura 2004, Miles, Sullivan, and Kuo 1998).

Many of the survey-based, public opinion studies examining relationships among attitudinal constructs and support for public policy to protect the urban forest have a strictly empirical approach. Zhang and others (2007) conducted a statewide telephone survey of 506 Alabama residents to determine how personal socio-demographic characteristics and knowledge of public urban tree programs related to favorable attitudes toward urban forestry initiatives. They formed their hypothesis based on the Contingent Valuation Method that measures values associated with public and non-market goods, advanced by Saz-Salazar and Garcia-Menendez in their 2000 article, “Willingness to Pay for Environmental Improvements in a Large City.” They found that individual characteristics such as race, gender, and residence were not statistically significant factors in explaining attitudes toward urban forestry programs. Sommer et al. (1990) surveyed 816 adults in eight California cities by mail to determine how socio-demographic factors (e.g., length of residence), experience with various types of trees (e.g., annoyances and benefits due to specific tree species’ characteristics) correlated with street tree preferences. No socio-demographic correlations were found except for a weak negative relationship between age and satisfaction with street trees. Among the entire sample, they found that benefits were mentioned more often than annoyances and correlated more highly with satisfaction with particular urban trees. Treiman and Gartner (2005) evaluated the responses from 7,338 Missouri residents in a mailed survey following Dillman’s (2000) methodology to determine how knowledge, importance of various aspects of managing and protecting trees, and socio-demographic characteristics (including community size) related to willingness to pay for a special “tree fund” and support for a tree ordinance. His findings suggest that residents of larger communities (i.e., the St. Louis and Kansas City suburbs) were more willing to pay for a hypothetical “tree fund” than residents of smaller towns. He attributed this difference to be partly because smaller communities may be more accustomed to lower levels of services and self-reliance to fix problems without government aid. He also found that younger respondents and those who had lived at their address for shorter periods, and higher levels of income and education were more likely to support the tree fund and a tree ordinance. Kathleen Wolf has been extremely prolific in her assessment of socio-psychological factors related to urban forestry (1998, 1999, 2003, 2004, 2005, 2006, 2007) having written a number of articles and reports reviewing studies of public attitudes the urban forest and successes of urban forestry programs in the U.S. through their positive contribution to communities (e.g., increased property values and traffic safety). She has also contributed to the knowledge base through surveys of community residents to link preferences (attitudes) about trees, willingness to pay for tree protection, and consumer behavior (Wolf 2005). Lorenzo and others (2000) mailed a questionnaire to 3,009 New Orleans households using Dillman's Total Design Method (1978) to gauge residents' willingness to pay for urban forest protection and preservation as a function of perceptions of the benefits of trees and the importance of publicly-funded urban forestry programs. They found that age, level of education, and type of residential ownership are not significantly associated with willingness to pay for tree preservation and protection, but the willingness to pay a higher premium for tree preservation and protection is directly related to income levels. Lohr and Pearson-Mims conducted nationwide telephone survey research on how socio-demographic characteristics and childhood experiences impacted positive attitudes and valuation of urban trees, as well as one's engagement with gardening and tree-planting activities as an adult (Lohr et al. 2004, Lohr and Pearson-Mims 2005). They concluded that growing up next to natural elements such as flower beds, visiting parks, taking environmental classes, and gardening during childhood were all associated with tree-related activities and positive adult values about trees. Most of the those interviewed appreciated trees, but those few people who placed less value on trees were more likely to have one or more of these characteristics: male, young, poorly educated, or with low income.

As shown in the literature review above of survey-based, public opinion studies examining relationships among attitudinal constructs and support for public policy to protect the urban forest, measures of social structure and personal characteristics (age, income, education level, gender, political affiliation, and length of residence) tended to have very modest relationships (if any) with support. Moreover, in two other recent studies using structural equation modeling to examine environmental concern, it was found that the addition of socio-demographic variables as a way to control the relationship between attitudinal variables and environmental behavior did not significantly improve the models (Cottrell 2003, Thøgersen and Ölander 2006). These more recent observations of the significance of socio-demographic and social structural variables on support for urban tree protection and other forms of environmental behavior and concern are in agreement with other earlier work which also found that attitudes, beliefs, knowledge, and other more substantive variables were more reliable in explaining variation in public support for the environment (for reviews see Jones and Dunlap 1992, Dunlap and Jones 2002).

It was of interest for the current research to seek out previous attitudinal studies that employed a social science-derived theoretical foundation to develop public opinion surveys, in order to advance sociological theorizing with regard to environmental concern about the urban forest. In 2004, Sasidharan and Thapa's review of urban forestry literature specifically identified the need for studies that linked socio-psychological correlates of environmental concern (e.g., attitudes) and socio-demographic characteristics with public acceptance of urban forestry programs ("behavior intentions"), referencing social theorizing developed by Schwartz (1992) (e.g., use of the instrument scale to measure environmental value orientations), Dunlap et al., (1992) (e.g., use of the NEP scale), and Stern et al. (1995) (e.g., use of measuring instrument assessing willingness to support environmental legislation). They concluded that a better understanding of social demographic and social psychological bases of urban and community forestry has great potential to assist urban forestry and park agencies in developing and implementing effective components of strategies.

Two significant theoretically-based studies were identified that used public opinion polling to link values with support for development of urban green spaces and urban tree protection. Balram and Dragícevíc (2005) built on Ajzen and Fishbein's (1980) theorizing to hypothesize that attitude is formed and affected by socio-economic, cultural and biophysical interactions to predict behavior, such as human response to policies and planning decisions for protection of green space. They used a modified version of the NEP scale (Dunlap, G. Gallup, and A. Gallup 1993) in a survey administered to 322 households in Montreal. In addition to value orientations, demographics, and knowledge, they also addressed the contextual dimension of environmental attitudes by interviewing 135 residents and allowing them to participate in a "collaborative GIS process" to identify common goals and strategies for urban green space conservation. This process involved drawing polygons on a digital map in responses to focused questions such as: "What are the area(s) that would benefit most from collaborative inter-municipality cooperation and agreement?" (p. 152). The results of their quantitative and qualitative analyses indicated that planners became more aware of the importance citizens place on the non-economic values of urban green spaces, while citizens became more aware of the complex trade-off decisions planners have to consider to optimize planning benefits.

GIS software was also used in the public opinion survey conducted by Tyrväinen et al. (2007) to develop a simple method to describe the "experienced qualities" of green areas for strategic green area planning purposes. The theoretical background for this study was grounded in environmental psychology and research related to how social values link to what people perceive as important qualities of green spaces, developed in part by Rachel Kaplan. Kaplan has contributed to the body of literature on urban forestry through her work examining psychological dimensions and stakeholder perspectives that contribute to support for urban forest policies (see R. Kaplan and S. Kaplan 1989 and Kaplan 1992 as examples). The study conducted by Tyrväinen and her colleagues tested a systematic approach to collecting social values as experienced by residents in urban green areas in Helsinki, Finland, through the use of a postal questionnaire sent to 1,000 random residents dealing with attitudes, values, and "use intensities" of urban woodlands. The questionnaire also included a map of the case study area for the respondents to indicate social values of designated green areas (e.g., "beautiful," "quiet," "opportunities for activity," "scariness," and "noise"). A database was created for the social value scores and imported into GIS, making it possible to present the results on a map and compare these valuations with actual landscape, vegetation and forest characteristics. In the synthesis map, several qualities often seem to be found within the same area, providing a snapshot of green area values and meanings for particular areas that could be rapidly compared with ecological and technical landscape features. This method facilitated a participatory approach that allowed stakeholders to easily communicate their opinions about environmental values of specific green areas to city planners.

In conclusion, the two studies described above demonstrated how "social spatialization" of landscape features may lend a further empirical approach to tease out the multi-dimensional aspects of environmental attitudes and behavior through the addition of local context, or "place." The three defining features of place – location, material form, and meaningfulness – have significance for social theorizing in that they work with actors' interpretations, representations, and identifications (Gieryn 2000). The assignment of place within a socio-spatial structure indicates distinctive roles, capacities for action, and access to power. Van Paassen (1976) builds on this thought:

> The so-called "spatial order" in fact is a societal order, which can be interpreted only as a social product resulting from the complex interplay of human perceptions, objectives, and capacities, institutional rules and material conditions connected with human and physical material substances in space. (Van Paassen 1976 in Shields 1988:36)

In other words, place mediates life; it is something more than just another independent variable (Abu-Lughod 1968 in Gieryn 2000). In the next section, it is shown how place theory may be combined with attitude-behavior theory to develop a combined theoretical framework that acknowledges the influence of the physical environment and the symbolic meanings attached to elements of the environment, such as trees, on attitudes and protectiveness of the urban forest (Stedman 2003a).

Importance of Place-Based Contexts in Environmental Sociology

Gupta and Ferguson (1992) point out that although space is a "central organizing principal in the social sciences," at the same time, "it disappears from analytical purview" (p. 7). Clearly, sociologists have acknowledged the significance of physical settings in social interaction, such as in Erving Goffman's theorizing on socio-spatial relations (1963, 1973) through his insights on the symbolic manipulation of space through staged "front spaces" and relaxed, less-strictly regulated "back spaces." However, studies of geographic settings and the built environment as *purely* sociological endeavors are less frequent, as compared to other disciplines' unabashed inclusion of physical "space" and "place" as prominent elements of theorizing (e.g., anthropology, geography, and psychology). Some have speculated that this may be because of sociologists' antipathy toward the suggestion of geographical determinism (Lofland 1993), or simply due to respect for the boundary between sociological and geographical imaginations (Agnew and Duncan 1989). At first glance, the perception of place as a "contextual force" that allows one to "predict" environmental attitudes and behavior may be regarded as a rather over-simplified way of viewing social spatialization (Stedman 2002, Stedman 2003a, Stern 2000, Gieryn 2000). However, social constructivism as a competing epistemology is a way around this dilemma. A constructive interpretation of place acknowledges the complex phenomena that make up "society" and the dynamic nature of the constantly changing conditions that define society in space and time. In short, "place" may be represented by physical objects assembled at a certain geographic spot and how actors interpret them.

With roots in phenomenology and interactionism, the use of a constructionist perspective in the social sciences grew in response to, and as a critique of, positivistic epistemology, and its tendency to reify social problems and distort how humans actually experience the world (Trentelman 2009). The concept of *place* is also a social construction: humans, acting as social agents, bring meaning to their environment by identifying concepts such as place, setting, community, or region (Brown 2005). In the quest to gain an understanding of how this *Sense of Place* drives our actions, environmental sociologists apply a social constructionist perspective that explores the common symbolic meanings of landscape features among different groups of people (Berger and Luckmann 1966). For example, Greider and Garkovich (1994) assert that natural environments assume different roles to different groups, depending on how a group defines itself. Many others have adapted social constructivism (as well as symbolic interactionism) to explore how *Sense of Place* impacts values, attitudes, and policy outcomes (Stedman 2003a, Black and Liljeblad 2006, Wilson 1980, Cheng and Daniels 2003).

Sense of Place is the meaning attached to a spatial setting by a person or group. Early qualitative studies argued that SOP was dependent on the depth of experience with settings (Tuan 1980) and social relationships with settings (Relph 1976). A three-component view of SOP predominates in social science: places include (1) physical setting, (2) human activities that occur there, and (3) human social and psychological processes (e.g., meanings and attachments) rooted in the setting (Brandenburg and Carroll 1995). Moreover, SOP may occur at a number of geographic levels: site-specific (e.g., Cades Cove in the Great Smoky Mountains National Park), area-specific (e.g., the Great Smoky Mountains), physiography-specific (e.g., the Southern Appalachian hardwood forest), or specific to a certain type of place (e.g., urban trees in a residential setting, the “geographic level” being studied in the current research). Regardless of definition or approach, however, many of those interested in the concept seem to agree that a *Sense of Place* is the perception of what is most salient in a specific location, which may be reflected in value preferences or how that specific place figures in discourse.

The cognitions that people use to relate themselves to the natural and social world are thought to have great potential for bridging the gap between the science of ecosystems and their management, through the integration of “place concerns” into the overall understanding of public attitudes about environmental issues (Stedman 2003b, Williams and Stewart 1998, Cantrill and Senecah 2001). Although much work has been performed to clarify the relationship between place-based concepts and environmental concern, SOP constructs remain poorly articulated.[6] In the effort to systemize relationships for SOP measurement, place researchers have often employed similar methodologies as (and sometimes in combination with) Catton and Dunlap's (1978) NEP scale, employing indices constructed from lists of carefully thought-out survey questions in a Likert scale format. Empirical treatments of the SOP construct(s) often focus on: (1) the multi-dimensional aspects (e.g., the importance of place attachment vs. place identity vs. place dependence), (2) SOP as an end in itself (e.g., factors that lead to place attachment), or (3) the effects of place attachment on other variables (e.g., place-protective behavior). Examples of these treatments are given below:

1) *Multidimensional aspects of SOP. Place identity, place attachment*, and *place dependence* are bonds that people establish with the surroundings in which they carry out their daily activities and go about their personal lives. Place identity involves "those dimensions of self that define the individual's personal identity in relation to the physical environment by means of a complex pattern of conscious and unconscious ideas, beliefs, preferences, feelings, values, goals and behavioral tendencies and skills relevant to this environment" (Proshansky 1978:155). Place attachment is described as a positive bond that develops between groups or individuals and their environment (Altman and Low 1992, Williams et al. 1992). It explicitly contains emotional content. Place dependence is defined by Stokols and Shumaker (1981) as an "occupant's perceived strength of association between him or herself and specific places" (p. 457).

2) *SOP as a function of underlying indicators.* In their followup 2006 study to the 2001 study described above, Jorgenson and Stedman again used the Williams et al. (1992) 12-item scale, but this time, they deployed it in a structural equation model which tested relationships of property and owner characteristics with the SOP constructs through three mediator variables: attitude towards shoreline development, attitude toward natural flora, and lake importance. They concluded that variation in the geographic areas and the specific environmental features indirectly impact SOP through mediating attitudinal variables that measure attitudes (as represented by attachment and identity) toward the geographic characteristics.

3) *Effects of SOP dimensions on place-protective behavior.* Norton and Hannon (1997) build on the idea that one's positive experience with a particular environmental setting leads to support for protecting it. They theorized that people value a place as more than

[6] Dimensions of SOP include place attachment, place identity, place satisfaction, place dependence, place responsibility, place protectiveness, nature relatedness, and place as a resource to exploit (Jorgenson and Stedman 2006, Nisbet et al. 2009, Norton and Hannon 1997, Hannon 1994, Devine-Wright 2009, and Stedman 2002, 2003a, 2006).

> simply a landscape that they “prefer” in an aesthetic fashion – *Sense of Place* pulls in “locally developed values, myths, and cultural practices” (p. 242). Moreover, because this evaluation process promotes “place-centeredness” behavior that results in “commitment to one’s own home and community” (p. 229), Norton and Hannon believe that an opportunity exists to explore how protectionist values from a range of local perspectives may be channeled toward support for policies of environmental protection.

An important theoretical clarification that Jorgenson and Stedman (2001, 2006) present is the tripartite composition of SOP: the conception of *Sense of Place* as comprising cognitive, affective and conative domains of human–environment relationships. By considering SOP as its own “attitude,” they suggested that improvements could be made in the organization of rather disorganized SOP constructs as well as to establish linkage to established literature of attitude theory with tested research methods. In their three-factor model of SOP for lakeshore property owners, they equated place attachment with the affective (or emotional) component of attitude; place identity with the cognitive domain whereby a place is part of the social actor's sense of self; and, place dependence as representing the conative domain of attitude in which the dependence expressed for one's setting is relative to the behaviors performed there. Counter to the authors' hypotheses, however, results suggested that a single evaluative dimension consistent with the definition of place attachment better explained the observed responses than did the other subcomponents of place identity and place dependence. They also concluded that the domains of attachment, identity, and dependence are distinct conceptually, but closely related empirically. Figure 2.2 presents the tripartite conceptualization of SOP.

Stedman (2003a) later introduced *place satisfaction* (the perceived quality of a physical setting) as an analytically distinct core concept making up SOP along with place attachment. His reasoning was that place satisfaction would help account for the role of the physical setting by revealing the degree to which the place of interest is liked or disliked. He defines place satisfaction as “’the utilitarian value [of a place] to meet certain basic needs,’ ranging from sociability to services to physical characteristics” (Stedman 2002:564). Past research in place satisfaction has shown that as an evaluative attitude, it is a very distinct concept from place attachment (Guest and Lee 1983, Hunter 1982). Acting as a function of objective attributes as they are subjectively assessed by community residents, place satisfaction could also be considered a conative attitude. This is because place satisfaction is often treated as a measure of quality of life (e.g., health and well-being) and systemic functioning

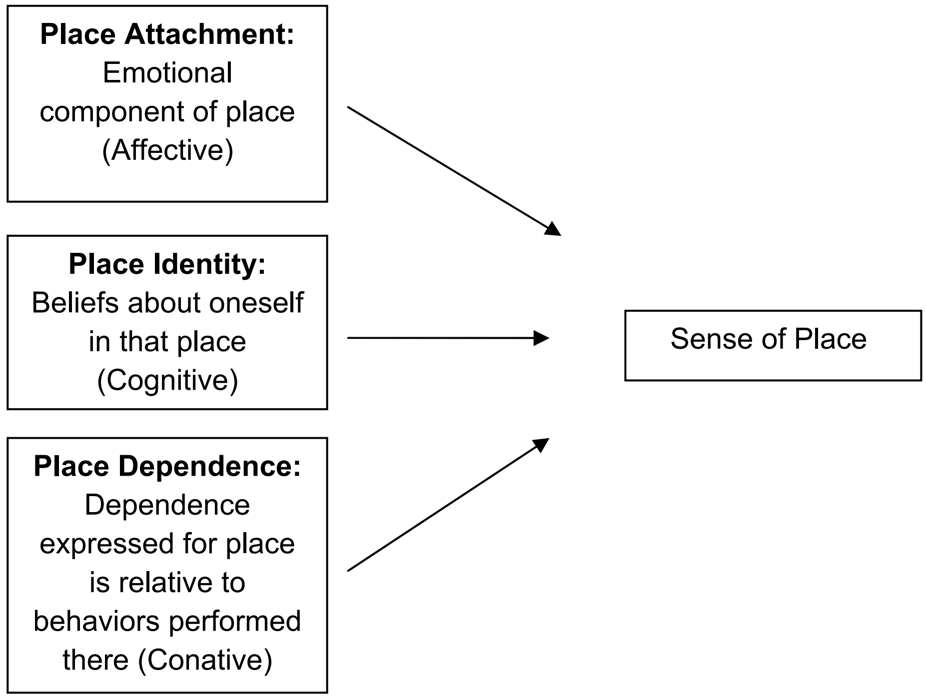

Figure 2.2. Place theory organized within attitude theory (Jorgensen and Stedman 2001).

of a community, and is defined by indicators such as presence of clean air and water, safety, noise levels, friendliness of neighbors, condition of housing, and general appearance (St. John, Austin, and Baba 1986, Brehm, Eisenhauer, and Krannich 2006, Stedman 2003a).

Stedman's (2003a) research of *place attachment* and *place satisfaction* used data from a questionnaire mailed in 1999 to 1,000 randomly selected Wisconsin lakeshore property owners, which asked about symbolic meanings they ascribed to lake living, as well as levels of place attachment and place satisfaction. Specifically, he measured "place meaning" by asking respondents their level of agreement ("strongly agree" to "strongly disagree" on a 7-point Likert scale) with answers to the question ''what kind of place is this?''[7] He measured "place satisfaction" by asking respondents to rate, on a 5-point Likert scale (''extremely satisfied'' to

[7] Stedman (2003a) described the lakeshore in his "place meaning" questions as "a place to escape," "the real 'up north,'" "a place of high environmental quality," and "a pristine wilderness" (p. 677).

‘‘extremely dissatisfied’’), various physical attributes of landscape features found at the lakeshore.[8] Finally, he measured “place attachment” by presenting nine items that assessed ‘‘how important is your lake to you,” which were also measured on a 7-point scale from “strongly agree” to “strongly disagree.” To relate the SOP measures and place-based meanings, Stedman tested a model with symbolic meanings as mediating variables in the relationship between physical lakeshore characteristics (e.g., lake size, turbidity, and color) and the two dimensions of SOP. This model was found to have an acceptable fit, and more importantly, there was not a significant direct relationship between lakeshore characteristics and place attachment or place satisfaction.

Along with place satisfaction and place attachment, Stedman also examined the role of *place meanings* which he calls “basis of attachment” or “basis of satisfaction,” depending on which SOP concept the meaning is being ascribed to. His inclusion of place meanings was predicated on Greider and Garkovich’s (1994) theorizing that humans attribute socially-constructed meanings to landscapes and in turn, become attached to the meanings themselves. He hypothesized that (1) meanings can be readily measured via level of agreement or disagreement with belief statements about the nature of particular physical settings, and (2) place meanings, which are outcomes of symbolic beliefs, experience, and awareness, mediate perceptions of the actual physical environment to produce a level of place attachment and place satisfaction. Stedman’s research lent support for both hypotheses.

Returning to Norton and Hannon’s (1997) idea that “place centeredness” (as a general SOP construct) leads to support for protecting that place of interest, others have specifically theorized about positive linkages between support for protecting the local environment and both place attachment and place satisfaction. In their survey of 449 Utah adults living in “high natural amenity rural community areas,” Brehm and others (2006) found “natural environmental attachment” to be a significant predictor of selective actions for maintaining or improving the quality of life in their community, including “importance of implementing new policies to protect the environment,” and “importance of preserving roadless areas.” Likewise St. John and others 1986) posited that place satisfaction, defined as “subjective evaluations of objective

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[8] Stedman (2003a) asked homeowners to rate satisfaction with lakeside attributes such as “scenery,” “water quality,” “Solitude/peacefulness,” and “fishing quality.”

neighborhood attributes," should be of great interest to policy makers who are interested in enhancing "community stability." They noted that unlike place attachment, which is defined more by a less tangible "social integration into the community," the environmental place characteristics that drive place satisfaction could be "manipulated" more easily by decision-makers through municipal expenditures.

Use of Geographic Information Systems (GIS) in Place-Based Social Research

GIS is a technology that analyzes spatially referenced data and maps the data to any spatially referenced data system. It has been in use since the 1960s, but use of GIS in the early years was limited to the public sector due to the very high costs involved in acquiring and operating the requisite mainframe computers. The awareness of the utility of GIS surged in the 1970s as a result of efforts by the U.S. Census Bureau to produce spatially-based output from the 1970 U.S. census. Also in the 1970s, intensive work began at U.S. and British universities to develop both vector- (line) and raster- (pixel) based mapping, contributing to the development of a large number of software packages for handling geographic information by the end of the decade. Following this innovative early period, the 1980s saw an era of commercialization as a result of data generation from satellite remote sensing and the emergence of personal computers. The past 15 years has seen an explosion in use in a broad array of social, economic and environment research as a result of inexpensive, user-friendly software (e.g., ArcGIS), the evolution of global positioning systems (GPS) and data recording instruments, and the development of publicly-available datasets. GIS is now positioned to serve as a mechanism to relate seemingly incongruous data in ways in which it had not been analyzed before, and to extrapolate valuable information from these new relationships (Longley et al. 2005, Galati 2006, Carocci et al. 2009).

There is an opportunity for fruitful collaboration between GIS and empirical studies examining SOP and environmental concern because of the power of GIS to examine systems spanning multiple spatial, temporal, and societal scales. Geographic research using GIS has been embraced by a variety of disciplines interested in including geographic concepts of place and space in the analysis of issues in crime and other human behavior, public health, environmental justice issues, environmental biology, and climatology through the lens of health sciences, anthropology, economics, regional science, and sociology (see Lee et al. 2008, Matei et al. 2001, Donovan et al. 2009, Duncan and Mummery 2005, Zahran et al. 2006).

Variation in the landscape is thought to be an important predictor for values such as landscape preference (Kaplan 1983). In order to find easily measurable, broad indicators of shared place-based preferences and values, research in land use policy has turned to GIS techniques for mapping biophysical features in conjunction with social values, to support land use planning efforts at multiple scales ranging from local, to regional, to national levels. This may include efforts to collaboratively map “landscape values” to capture components of SOP through community residents’ identification of common “special places” and assignment of a typology of values to these places (see Brown 2005 and Alessa, Kliskey, and Brown 2008), or by seeking out biophysical “integrative indicators” that may serve as proxies for widely held social values (see Norton and Steinemann 2002). Integrative indicators may include impervious surfaces, tree canopy density, open green space, distance to outdoor recreation areas (e.g., shorelines and national parks), and development intensity.

As another example of social research using integrative indicators, a Dutch GIS-based landscape appreciation model called GLAM, has been developed based on the “psychophysical” paradigm which states that references for and the attractiveness of a specific landscape are supposedly founded in the landscape’s physical attributes (De Vries, Roos-Klein Lankhorst, and Buijs 2007). GLAM predicts the attractiveness of the landscape based on nationally available GIS data such as “naturalness” (e.g., presence of surface water), topography, and “skyline disturbance” (e.g., tall industrial buildings) for a map divided up into 250 × 250 meter cells. Although it is cautiously used by policy-makers who are interested in local resident appreciation of biophysical features, it is primarily used for monitoring purposes to give early warning signs that the landscape may be changing in a way that makes it less “attractive.”

Summary

The key motivating factor behind work using GIS to measure or predict social landscape values has been to investigate the extent and nature of spatial variations in measures that take place on the individual level, in order to determine contextual differences (Duncan and Jones 2000). Instead of viewing “place” and “region” in purely descriptive and idiographic terms, geographic research acknowledges that there may be important people-place interactions that impact contextual effects in systematic ways. This dissertation research builds on the work of other social scientists who have used GIS-based approaches to critically reflect upon – and present theorizing within a sociological context – on how regions/places can be constituted by and constitutive of social life, relations, and identity (Paasi 1991).

The following propositions are derived from the review of the literature from *Sense of Place* studies, attitudinal studies, and urban forest management research. The propositions are intended to guide analyses and interpretation:

1) Can the theoretical perspectives of attitude theory and place theory be linked to serve as a tool for planning and to gain a better understanding of “areas” of agreement in a community for negotiating strategies to protect the urban tree canopy?

2) Can GIS technology and its diffusion play a transformative role in better understanding the effect of place on community attitudes toward environmental protection?

3) Can spatial data be analyzed to shed light on physical factors triggering public perception of the importance of environmental protection of trees?

4) Can GIS analysis provide direction to policy makers on how to garner public acceptance for government initiatives meant to improve environmental sustainability on a community level, first, then applied to a more regional approach?

These propositions are used to further clarify the theoretical framework developed in this dissertation research, forming the basis for testable hypotheses presented in the next chapter.

CHAPTER III

SUMMARY OF RESEARCH AND HYPOTHESIS DEVELOPMENT

This dissertation research combines attitude theory and place theory into a single theoretical framework which is hypothesized to help better predict support for environmental policy, specifically policies to protect the urban forest canopy. Attitude theory, upon which the study of attitude-behavior relationship rests (Routhe et al. 2005, Dunlap and Jones 2002, Ajzen and Fishbein 1980), and place theory which identifies SOP as a special type of "attitude" (Stedman 2002, Stedman 2003a, Cheng et al. 2003, Norton and Hannon 1997, Altman and Low 1992; Relph 1976), share the tripartite conceptualization of attitude as containing cognitive, affective, and conative dimensions. The model is revised from various models (Stern 2000, Thøgersen 2006, and Kollmuss and Agyeman 2002) and seeks to present a comprehensive view of the factors that play a role in individual decisions to support urban forest protection policy. The role of the distinct attitude dimensions, the biophysical characteristics of the homeowner's *place*, life experience with trees and landscaping, and knowledge of trees in explaining variation in support will verified through structural equation analysis. Figure 3.1 presents the proposed model.

Of particular interest is the role of urban forest place attachment and place satisfaction in mediating the degree that tree experience and tree knowledge predict support for tree protection and management policies. First in the causal chain are measures of life experiences (e.g., experience with trees and landscaping) and knowledge about trees. Place meanings are produced from experience with and knowledge about trees, and these meanings in turn underpin urban forest attachment and satisfaction (components of SOP). These intervening variables of SOP are not measured directly, but estimated by looking at measurement of tree canopy density around each homeowner's house, the homeowner's reported "basis of attachment," or attitudes about the urban forest, and the homeowner's reported "basis of satisfaction," or importance of urban forest features in his/her home area. Finally, the proposed model places SOP as the direct causal antecedent of support for tree protection policies (behavior intention), as theorized by Brehm et al. (2006), Larson and Santelmann (2007), Cheng et al. (2003) and Gieryn (2000). The development of these constructs is further

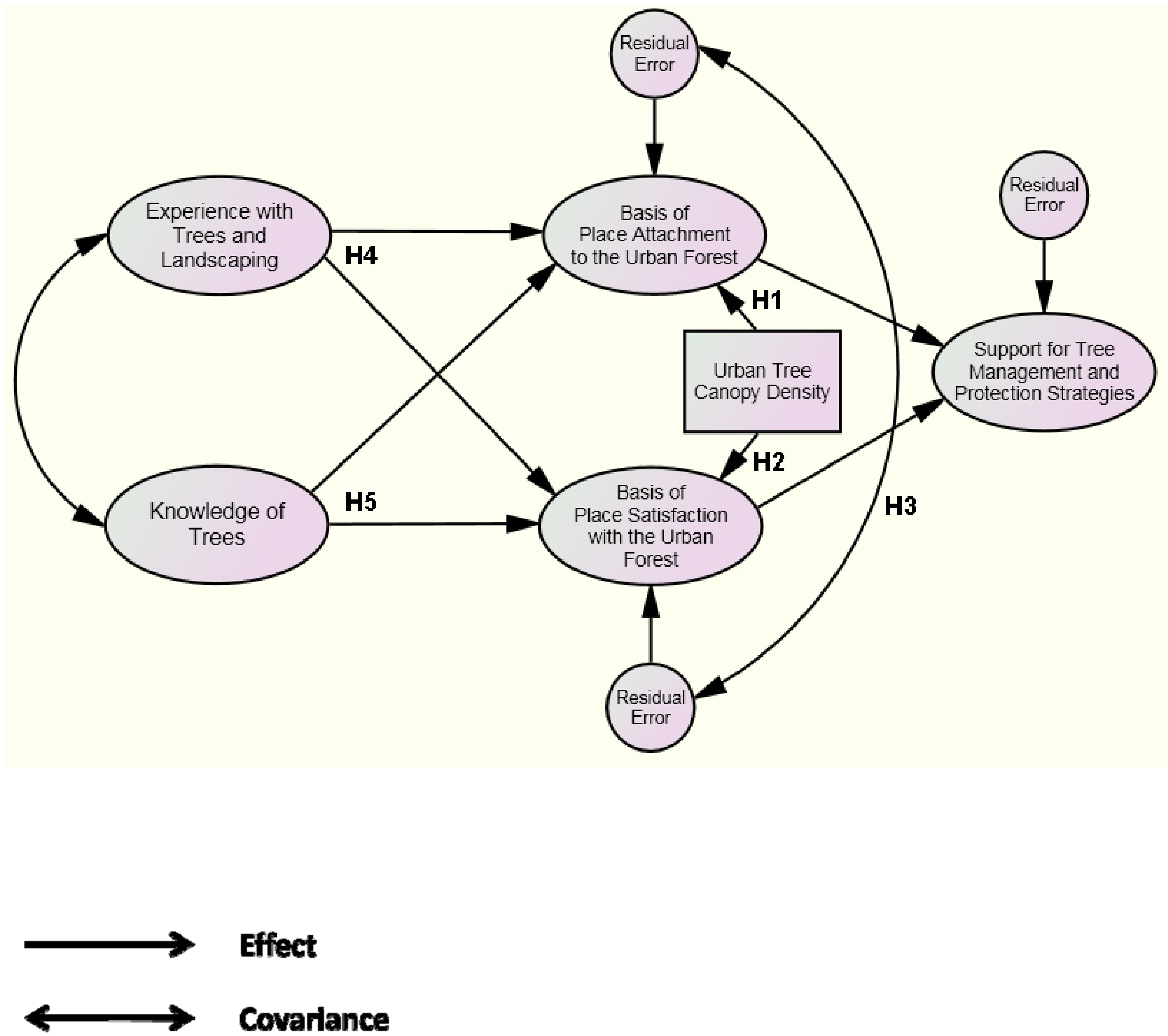

Figure 3.1. Generalization of proposed model, showing how *Sense of Place* (as represented by *Basis of Place Attachment*, *Basis of Place Satisfaction* and *Urban Tree Canopy Density*) mediates the influence of *Experience* with trees and landscaping and *Knowledge* of trees on *Support* for tree management and protection strategies.

discussed in Chapter 4.[9]

This chapter presents a series of hypotheses to be tested which are related to the proposed model, supported by summaries of the literature related to each hypothesis. The proposed model expands the treatment of SOP to encompass the "cognitive hierarchy" of attitudes and potential behaviors toward "attitude objects" (e.g., spatial landscape objects, as represented by urban trees in the current study) which helps to organize hypotheses while remaining true to important theoretical precepts. The development of the SOP constructs, *Place Attachment* and *Place Satisfaction*, are discussed below, along with the components of the model presented in Figure 3.1. The chapter concludes with a summary of the theoretical justification for the hypothesized model.

Place Attachment and Place Satisfaction as "Sense of Place"

In the crudest sense, early humans were attached to a particular landscape simply because of physical characteristics that were present. For example, certain landscape features promoted survival (e.g., caves for refuge and the savanna as a habitat of foodstuff) (Riley 1992). Place attachment as a culturally and socially determined phenomenon came later in history, as the environment began to serve as a setting for other human organization of space and time. Human interaction with the land came about first through the use of technology and resource extraction, and later evolved into a conscious bonding. Human bonding with the landscape incorporated narrative and symbolic processes to define "place," resulting in a congruence of culture and landscape that formed the basis of regional identity (Wimberley 2009). *Sense of Place* discussed in this dissertation builds on these social and psychological aspects of place bonding, where the landscape serves to link people together and serve as an attraction for affective attachments that stimulate memories, ideas, or other feelings. At this point, "place" is more than just a physical setting for human activity, but a "milieu which embeds and is a

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[9] As shown in the literature review of survey-based, public opinion studies examining relationships among attitudinal constructs and support for environmental policy, measures of social structure and personal characteristics (age, income, education level, gender, political affiliation, and length of residence) tended to have very modest explanatory power. Therefore, in the interest of creating a model that reflects the most parsimonious synthesis of the environmental concern literature, the current study uses tree/landscape experience and tree knowledge to represent social-structural characteristics.

repository of a variety of life experiences, is central to those experiences, and is inseparable from them" (Low and Altman 1992:10).

Richard Stedman's 2002-2003 work in modeling SOP recognized this "essence" of place when he hypothesized that physical landscape characteristics underpinning place-based symbolic meanings, which in turn are associated with one's *Sense of Place* as described by *place attachment*. Research has associated stronger place attachment with greater inclination to protect special places. The relationship between SOP and environmental concern (expressed as "place protectiveness" or "support for environmental legislation") has also been explored not only by Stedman, but many others (Davenport and Anderson 2005, Brehm et al. 2006, Larson and Santelmann 2007, Devine-Wright 2009, Norton and Hannon 1997). SOP is commonly explored in terms of place attachment (or the closely related construct place identity) and the activation of place-protective behavior in response to proposed changes to forests, open space, or shorelines (e.g., residential development or construction of wind farms). As suggested by the model in Figure 3.1, social psychological theorizing linking attitudes and behavior (see Ajzen 1991, Stern et al. 1995, Routhe et al. 2005) forms the basis for the hypothesized relationships linking SOP and place protectiveness.

In the current research, the concept of place attachment was operationalized through (1) indicators measuring urban forest place meanings (e.g., "trees in cities help people to feel calmer") that are indicators of the latent construct *Basis of Attachment* and (2) urban forest *Canopy Density*. These two variables are similar in conception to Stedman's lakeshore "place meanings" (e.g., "a place to escape") and physical lakeshore characteristics (e.g., turbidity) that he related to place attachment to the Wisconsin lakeshore. Stedman also showed that place meanings mediate the relationship of physical place characteristics with place attachment, and that higher place attachment is associated with greater willingness to engage in place-protective action (Stedman 2002, 2003a).

Accordingly, I hypothesize:

H1. Urban tree *Canopy Density* in the place where people live is positively and directly related to *Basis of Attachment* to urban trees, which mediates the relationship between *Canopy Density* and *Support* for urban tree protection and management strategies.

According to H1, the presence of trees helps to form positive place meanings about landscapes that include trees. The *place attachment* that is formed from living in a place that has physical characteristics that are appealing (urban trees) contributes to intentions to protect that place.

Returning to the concept of *place satisfaction*, which Stedman (2002) suggests is viewed by some as a more "shallow" contributor to SOP than place attachment, and "strangely absent" from SOP literature but prevalent in community sociology (Stedman 2002), he concludes:

> As a summary evaluative judgment about a spatial setting as object, satisfaction corresponds well to classic definitions of attitude or a summary judgment based on a collection of beliefs about an object that may predispose action toward it. (p. 564)

The relationship of place satisfaction to behavior is also circumspect. Stedman considers two possibilities: will people who have higher satisfaction with their surroundings be more willing to engage in behavior such as place protectiveness, or is there an inverse relationship: low satisfaction leads to higher tendency to fight for positive change to create a better situation? He opts for the latter – that concerns are more apt to come to the forefront in the form of activism when one has lower place satisfaction.

In the current research, I am taking the opposite stance: that place satisfaction spurs people to support the idea for greater protection of the local tree canopy. As a form of attitude, the construct of urban tree place satisfaction is conceptualized to rise in value in response to placing greater importance on various tree attributes in combination with the presence of tree canopy in one's neighborhood. To relate place satisfaction to the current research, I turn to research in landscape preferences by Kaltenborn and Bjerke (2002). They define a "landscape preference" as "a positive evaluation of an environment that people are involved in, identify and associate with, and receive a *feeling of satisfaction* from" (p. 393). In their work looking at associations between place attachment and preferences for local landscape in Norway, they found a positive correlation between place attachment and landscape preference. If landscape preference is defined in similar terms as place satisfaction, then one may infer that place satisfaction is also positively correlated with *Place Attachment*. Since *Place Attachment* is hypothesized to be positively related to *Support* (H1), then one may deduce that *Place Satisfaction* is also positively related to *Support.*

Similar to the place attachment concept, the current study operationalizes place satisfaction through (1) indicators measuring importance of urban forest place characteristics (e.g., "trees improve air quality”) that are indicators of *Basis of Satisfaction* and (2) urban forest *Canopy Density.* These two variables are similar in conception to Stedman’s measures of “elements of satisfaction” with the lakeshore (e.g., “scenery”) and physical lakeshore characteristics (e.g., turbidity) to relate to his *place satisfaction* variables. Stedman also showed that place meanings mediate the relationship of physical place characteristics with place satisfaction.

Accordingly, I hypothesize:

H2. Urban tree *Canopy Density* in the place where people live is positively and directly related to *Basis of Satisfaction* with urban trees, which mediates the relationship between *Canopy Density* and *Support* for urban tree protection and management strategies.

According to H2, the presence of trees raises awareness of the importance of the ability of trees to improve the aesthetics of an area (e.g., “mark seasonal change” and “produce attractive blooms”) as well as to improve physical quality of a community (e.g., “improve air quality”). The *place satisfaction* that is formed from living in a place that has physical landscape characteristics (urban trees) that contribute to enhanced functioning of one’s relationship to the surrounding environment is thought to directly influence one’s desire to protect that aspect of the landscape.

Stedman (2002) also suggests that place attachment and place satisfaction are positively correlated (p. 564). This is also suggested by research by St. John and others (1986), who found that satisfaction with the environmental conditions of neighborhoods has an important positive effect on attachment. Thus:

H3. *Basis of Attachment* to urban trees and *Basis of Satisfaction* with urban trees are positively related.

This means that a person for whom a forested landscape has positive meanings, probably also thinks that areas with trees are important for practical reasons, such as to improve air quality and reduce street noise.

Experience

How an individual perceives the world is multi-dimensional and involves a variety of attitudes and individual perceptions based on personal experiences. As suggested by the biophilia hypothesis, humans require contact with a biodiverse world to stimulate the development of their emotional, cognitive, and social potential (Kellert and Wilson 1993). Ewert, Place, and Sibthorp (2005) suggest that outdoor experiences early in life lead to "eco-centric" attitudes by nurturing lifelong positive affective feelings from positive memories of a specific natural environment and the development of corresponding subjective norms. Kalterborn and Bjerke (2002) posit that personally experienced social construction of specific places symbolize and create environmental meanings that form a sense of attachment. Takács-Sánta (2007) theorized that direct "sensory obtainment" of environmental problems and risks leads to an increase in environmental concern. Nisbet and others (2009) developed a "nature-relatedness" attitudinal construct linked to spending time outdoors in the natural environment.

Although the findings relative to the impact of life experience on attitudes such as SOP (as described by place attachment and place satisfaction) are mixed, they are adequate to warrant proposing a direct positive effect. Accordingly, I hypothesize:

H4. *Basis of Attachment* and *Basis of Satisfaction* mediate the relationship between *Experience* with trees and landscaping and *Support* for tree protection and management strategies.

According to H4, just because a person has experience living around and caring for trees, doesn't mean that this person automatically supports urban forest protection policy. However, people who attribute meaning to urban forests and place importance on the contributions of trees are more likely to have greater acceptance of policies to protect trees if they have also spent time planting, caring, and actively learning about how to do these activities better.

Knowledge

Knowledge (a cognitive component of attitude), is an important expression of environmental concern discussed in the literature, although it is generally considered to be "specific and narrow type of cognition or belief" that is just a "modest" predictor of actual environmental behavior (Dunlap and Jones 2002:495). The indirect linkages between knowledge and behavior presented in the literature include examples of behavior that may occur due to: awareness of consequences of not attending to an environmental problem such as climate change (Stern et al. 1995); “subjective norms” that come about as a result of peer pressure or guidance from significant others to perform a given action (originally validated by Fishbein and Ajzen’s Theory of Reasoned Action in 1975 and later adapted to environmental behavior by Routhe and others in 2005); or a desire to protect the environment which brings about environmentally responsible behavior such as recycling (Cottrell 2003). There have also been numerous studies linking knowledge/awareness of environmental problems (and risk) to support for policy initiatives addressing a perceived threat (Slimak and Dietz 2006, Stern 2000, Zahran et al. 2006).

As with the *Experience* construct, the findings relative to the impact of *Tree Knowledge* on attitudes such as SOP (as described by place attachment and place satisfaction) are varied. However, these studies provide adequate evidence to warrant hypothesizing a direct positive effect on environmental attitudes. Accordingly, I hypothesize:

H5. *Basis of Attachment* and *Basis of Satisfaction* mediate the relationship between *Knowledge* of trees and landscaping and *Support* for tree protection and management strategies.

Similar to the H4, H5 means that just teaching people about trees is not going increase their willingness to want to protect trees in their community. However, people who attribute meaning to urban forests and place importance on the contributions of trees are more likely to have greater acceptance of policies to protect trees if they also understand how to identify healthy trees, plant a tree, trim trees, and other aspects of tree knowledge.

Summary

The purpose of this dissertation research is to elucidate the connection among people, place, and politics within the context of support for urban tree canopy protection. The urban forest is rooted in a community space that enables and constrains *Sense of Place* through its own unique character. Is it possible to reconstruct approaches to urban forest management that embed policy decisions in place-based social and ecological relations? Other considerations are as follows. First, there is an urgent need to not only look at the human impact of deforestation, but also to consider processes that govern human activity itself. The current research is drawing from attitude theory, since an effective environmental policy such as a tree ordinance relies on local knowledge, beliefs, and values on how to manage the ecosystem. Second, SOP (as described by place theory) influences collective action in that it assigns certain shared meanings and expectations of appropriate behaviors to a particular place. This is significant because there is potential to discover common place-based group identities that do not rely on conflict such as what typically drives the highly positional rhetoric of traditional politics. Third, with regard to natural resource politics, environmental management strategies as an outcome directly transform and/or sustain the community "place" by imposing direct effects on natural resources such as urban trees. Finally, GIS helps to bridge the gap between qualitative, place-based meanings from a social construction standpoint *and* a quantitative approach that allows an empirical analysis of potential concrete outcomes of SOP, such as support for environmental policy. The validity and utility of this multidimensional approach is tested theoretically with reference to attitude theory and place theory, and shown empirically by utilizing path modeling techniques.

CHAPTER IV

RESEARCH STRATEGY

The current study employs geographic information systems (GIS) to measure spatial data in the form of tree canopy density in combination with geocoded socio-psychological indicators from a public opinion survey conducted in 2005 of Knox County homeowners. Social and ecological data were obtained to examine the relationship among social and tree canopy structure as described by the hypothesized model. Social data consisting of socio-demographic characteristics, attitudes, beliefs, knowledge, and life experience were obtained via a mailed questionnaire. Ecological data were obtained from publicly-available GIS data depicting tree canopy cover in Knox County. Social data were imported into GIS using ArcView 9.3.1, making it possible to present the results on a map, combine it with other geographical information, and perform further analyses.

The purpose of this chapter is to present the methodology of this study, and is divided into five sections. The first section includes a description of data collection procedures, the study area, the survey instrument and how it was designed. The population and sampling, mailing procedures, and data documentation procedures are also discussed. Next, survey sample characteristics are described, including the hypothesized constructs of *Experience with Trees and Landscaping* (Experience), *Tree Knowledge* (Knowledge), *Basis of Satisfaction with Tree Places* (Basis of Satisfaction), *Basis of Attachment to Tree Places* (Basis of Attachment), and *Support for Local Tree Protection and Maintenance Policies* (Support). The third section provides a description of spatial analysis procedures, consisting of measurement of urban tree canopy density, how this biophysical measurement was conceptualized to help form S*ense of Place* with the components of *Basis of Satisfaction* and *Basis of Attachment*, and geographic information systems (GIS) procedures. The fourth section provides an overview of the structural equation modeling (SEM) procedures, including testing of model fit, model improvement, how missing data is handled, and implications of normality and categorical variables in SEM. This fourth section concludes with an outline of the two steps undertaken in SEM: confirmatory factor analyses (CFA) of the model's individual constructs and deployment of the measurement model (Step 1), and structural model evaluation (Step 2). A summary of the research strategy is provided at the chapter's end.

Data Collection and Organization

This section provides a description of the study area, how the questionnaire was conceived and developed, justification for using homeowners as a sample group and the number of surveys initially mailed, actual mailing procedures, and a description of how the data was collected and documented.

Study Area

The geographic setting for this case study, Knox County, was established on June 11, 1792, and was named after George Washington's Secretary of War, Henry Knox. The City of Knoxville, the county seat, initially served as the capital of state of Tennessee following its formation in 1796. Knoxville was incorporated in 1815 (Deaderick 1976). Knox County has a total area of 508 square miles and an estimated 2009 population of 435,725, and Knoxville covers 92 square miles with a 2006 estimated population of 182,337. The town of Farragut is also located within Knox County and has a total area of 16.2 square miles and a population of 17,720 (U.S. Census Bureau: State and County QuickFacts). Water makes up 17 square miles of Knox County, or 3.3 percent of the total surface area (U.S. Census Bureau 2011). In the southeast part of Knoxville, the French Broad River (flowing from Asheville, North Carolina) joins the Holston River (flowing from Kingsport) to form the headwaters of the Tennessee River. Knox County is comprised of 174,327 acres of tree canopy (52%), 91,380 acres of open space (27%), 44,019 acres of impervious surfaces (13%), and 15,847 acres of bare ground (5%). The dominant land cover in Knoxville is trees, covering 25,151 acres (40%). Impervious urban surfaces comprise 16,981 acres (27%). Open space accounts for 21 percent of the city's landscape (13,105 acres) and bare land accounts for 4,276 acres (7%) (American Forests 2002).

Knox County has been experiencing loss of tree canopy, as indicated by an Urban Ecosystem Analysis undertaken by American Forests, a national non-profit that works with communities to protect and restore forests (American Forests 2011). The Urban Ecosystem Analysis for Knox County (one of 40 such studies throughout the U.S. conducted by American Forests), indicated a decline in tree canopy throughout the county from 1989 to 1999 (American Forests 2002). The recognition of this problem in Knox County resulted in the creation of a local tree ordinance for the city of Knoxville in 1992 (City of Knoxville 2011). A tree ordinance empowers planning officials and urban forestry personnel to inspect and regulate the maintenance, planting and necessary destruction of city trees. Knoxville's tree ordinance established a Tree Board and required the city to hire a municipal arborist to protect trees. The ordinance stipulates that eight trees per acre be planted on new developments and prohibits cutting more than a quarter of the trees on an undeveloped lot within a five-year span. Cutting a large tree near a building built before 1860 is also prohibited. The city arborist can exempt properties from these rules, but exemptions are rare and fines ($50 per incident) almost non-existent because requirements are easily met. Outside of the city limits, the zoning ordinance for Knox County calls for the planting of certain numbers of trees around commercial telecommunications facilities (i.e., cell phone towers), parking lots, front setback areas, rear yards, and side yards of commercial and mixed-use developments. However, no provisions are made for the size of the plantings or types of trees other than "native shade trees," "ornamental trees," or "evergreen trees." There are also no regulations for protecting existing trees in Knox County except a broad statement to preserve trees "in the design of the subdivision, wherever possible" (Metropolitan Planning Commission of Knoxville-Knox County 2011).

Survey Design

The framework of the mail survey design was first developed in the Spring of 2004 as part of Dr. Robert E. Jones' Advanced Survey Design and Analysis class (Sociology 633) at the University of Tennessee, Knoxville (UT). Survey questions were formulated through extensive review of urban forest and attitude research literature. Graduate students in Sociology 633 reviewed preliminary drafts of the questionnaire. Later that same year, funding was provided by the United States Department of Agriculture Forest Service; Tennessee Department of Agriculture, Division of Forestry; and the UT Waste Management Research and Education Institute to develop the instrument further and send it by mail to a random sample of adult homeowners living in Knox County. During modification of this questionnaire in 2004, further input was obtained from the citizen-based Knoxville Tree Board and members of the Knoxville Tree Board's Planning/Tree Ordinance Committee, led by the Comprehensive Planning Manager of the Knoxville/Knox County Metropolitan Planning Commission (MPC). During 2004, this committee developed *The Knox County Tree Conservation & Planting Plan* (Plan), which addressed conservation and planting issues in Knox County (Metropolitan Planning Commission of Knoxville-Knox County 2007). The Plan also discussed the potential of expanding the Knoxville Tree Board to a county-wide Tree Board. MPC conducted focus group meetings and implemented a pilot web-based survey in October and November of 2005, and these results were used to gather ideas for further refining the mail survey used in the current study. The draft mail survey was finalized to incorporate concepts discussed at these meetings and highlighted in the draft Plan. In July 2005, the draft survey was forwarded to 20 stakeholders from the Knox County region to review the survey draft. Feedback was obtained from 13 of the 20 stakeholders on ways to improve the survey. Also during July 2005, UT's Office of Compliance and Contracts-Institutional Review Board (IRB) conducted a "human subjects" review of (1) the research proposal to conduct the study and (2) a draft version of the questionnaire. The study and its questionnaire were subsequently approved by the IRB on July 18, 2005.

The measurement scales used to form the study constructs were adapted from the literature and, in some cases, modified to fit within the context of attitudes about the local urban forest. The final version of the questionnaire used in the study contained 90 questions. Included were 15 socio-demographic questions (e.g., age, gender, income, length of residency), 14 questions to measure the level of experience with trees and landscaping, 9 questions to determine the level of knowledge about trees in general, 10 questions to gauge the importance of trees were to the respondent, 15 questions to identify public attitudes toward tree-related issues, and 6 questions to gauge public support/opposition for local tree protection and maintenance policies. Items were measured by either "yes" or "no" responses, or Likert scales with ranges of 3 to 5 possible responses. Respondents were given an opportunity to provide open-ended comments on the back of the survey booklet. A space was provided for the respondent to provide a mailing address if he or she wished to receive a summary of the survey results. The Appendix presents the survey instrument.

Population and Sample

The questionnaire was mailed to adult (18 years or older) residents who were also single-family homeowners in Knox County, Tennessee. Homeowners were selected as a study group because they regularly make decisions that affect the urban tree canopy through management of their own homes, yards and neighborhoods. Also, homeowners have a vested interest in public expenditures, unlike more transient renters (Barreto, Marks, and Woods 2007, Clendenning, Field and Kapp 2005, Youngentob and Hostetler 2005). Specifically, the homeowner population targeted was those adults who lived only in single-framed houses, and excluded renters as well as those who owned or lived in condominiums, duplexes or townhouses.

At the time of the sample collection, it was estimated that there were 86,386 single-family households in Knox County (Survey Sampling International 2005). To achieve a 95 percent confidence interval and a sampling error of plus or minus five percentage points for this population, it was necessary to obtain 382 completed surveys from this population (Salant and Dillman 1994). In order to have the flexibility to compare sub-populations within Knox County, the number of returned and completed questionnaires necessary for this same confidence level and precision was doubled to 764. Based on these estimates and upon conservative assumptions about the percentage of eligible respondents in the sample, likely response rates for the mailing, and number of usable questionnaires returned, a random sample of 2,400 households located in Knox County was obtained from Survey Sampling International of Fairfield, Connecticut (SSI). The names and addresses of the head of these households were included in this sample, and were subsequently mailed the study questionnaire.

Mailing Procedures

The mail survey employed a four-wave mailing approach designed to improve mail survey rates (Salant and Dillman 1994). The first wave included an introductory letter personally hand-addressed to potential respondents explaining how they were selected and the purpose of the survey. A second hand-addressed envelope containing a letter, questionnaire, and a stamped business-reply envelope followed. The third mailing was a postcard reminder thanking respondents who had already returned questionnaires and encouraged those who had not yet returned them to do so as soon as possible. Finally, a fourth mailing was a hand-addressed letter sent to every potential respondent who had not yet returned a blank or completed questionnaire. The mailing cycle began on October 24 and ended on November 14, 2005. Surveys were returned between November 9, 2005 and February 2, 2006.

Data Collection and Documentation

All returned survey materials were received at the mailroom of the UT Energy, Environment and Resources Center where I had my office. Surveys returned each day were marked with their arrival date before entering survey responses into a digital data file using Statistical Package for the Social Sciences, version 13.0 (SPSS). This SPSS file did not contain any identifying information about the survey respondents and was cross-referenced with a Microsoft Excel file that was used to track response rates using a unique survey identification number. Open-ended responses were entered into a Microsoft Word file and sorted according to survey identification number. Although the time period for the survey was officially from October 24, 2005 to December 20, 2005, 22 more completed questionnaires arrived between December 20, 2005 and February 2, 2005. These were also documented and entered into SPSS.

Survey Sample Characteristics

This section details survey sample information, including the response rate, representativeness, and a detailed breakdown of the socio-demographic characteristics of the survey respondents.

Response Rate and Representativeness of Collected Data

A total of 976 completed questionnaires were received. The initial sample size of 2,400 potential respondents was reduced by 56 to 2,344 after the mailing was completed (see Table 4.1). These 56 subjects were not eligible to represent the target population either because they were deceased, they were no longer living in Knox County, they had refused the survey due to age or illness, or the survey was sent to an undeliverable address. Of the remaining 2,344 questionnaires sent to eligible respondents, 1,301 were not returned and 67 were returned

Table 4.1. Breakdown of the mailing.

Category	Number	Percent
Questionnaires Mailed	2,400	100.0
Deceased	4	<1.0
Non-deliverable	47	2.0
Refused due to age or illness	5	<1.0
Eligible Respondents	2,344	97.7
Questionnaires received by Eligible Respondents	2,344	100.0
Unreturned questionnaires	1,301	55.5
Questionnaires returned blank	67	2.9
Completed questionnaires	976	41.6

blank. The 976 returned and completed questionnaires from eligible respondents represented a 42% response rate.

The 42% response rate reflects the average mail survey response (average range, 35-45%) that has been historically obtained from a variety of surveys conducted in Southern Appalachia that obtained random samples of the general public (personal communication, Dr. J. Mark Fly, Director of the UT Human Dimensions Laboratory). Similarly, seven recent in-depth studies on urban trees that used large random samples (n > 300) of the general public reported response rates ranging from 27 to 55 percent, with the average being 43 percent (Balram and Dragicevic 2005, Lohr et al. 2004, Lohr and Pearson-Mims 2005, Lorenzo et al. 2000, Treiman and Gartner 2005, Tyrväinen et al. 2007, Zhang et al. 2007). Moreover, according to Treiman and Gartner (2005: 244), "response rates to such surveys have declined appreciably over the last 30 years, with the 'average' mail survey obtaining a response rate of around 65% in the 1970s but only around 45% by the year 2001" (also see, Connelly, Brown, and Decker 2003 with regard to resource-related mail surveys).

The extent to which a randomly selected sample of respondents represents the target population mostly depends upon the number of completed questionnaires returned by eligible respondents. A randomly selected sample of 976 eligible respondents provides an accuracy level of ± 2.4 percentage points (i.e., the confidence interval). Overall, this means that 95 out of a 100 times (i.e., at a confidence level of 95 percent) a random sample of this size (n= 976) is drawn, the sample results should be within ± 2.4 percentage points from the true value of the targeted population. Sampling error is the basis upon which tests of statistical significance can then be calculated from sample results.

"Completeness" of survey responses was assessed by determining which respondents did not complete enough of the survey to provide meaningful results. If the respondent did not answer 20 or more questions out of the 90 questions, that case was discarded. There were 38 surveys that were discarded because of incompleteness, bringing the total number of respondents in the usable data set to 938. The 938 cases were then examined to remove respondents who were not single-family homeowners. Although the sample provided by SSI for the analysis targeted "single family dwelling households," respondents were given the opportunity to self-report whether they resided in a dwelling other than single family houses (e.g., multi-family, condominium, or apartments) in Q29 (see the Appendix). Respondents also self-reported whether they (or a family member) owned their house (either outright or through a bank mortgage) or rented their house, in Q28. These cases, along with cases where homeowners did not live in single family homes, were subtracted from the initial data set. After these deletions were made, the final dataset contained 800 cases representing the responses of homeowners living in Knox County. The revised sampling error, based on n=800, a 95 percent level of confidence, and targeted sample of 2,344 homeowners, was ± 2.8 percentage points.

The sample size had important implications for the structural equation modeling procedures described later in this chapter. The sample size (n = 800) met the minimum requirement that 200 or more cases are desirable to test a complex structural equation model (Hulland et al. 1996). This large sample size also met the 20:1 requirement for the ratio of sample size to the number of model parameters that require statistical estimates (Jackson 2003).

Socio-Demographic Information and Representativeness of Knox County

The last section of the questionnaire contains demographic information of respondents, such as age, gender, and ethnicity. Socio-demographic characteristics were measured by 15 questions: Q22 – Q35 and Q17 (see the Appendix). These questions asked the survey respondent to report his/her age, gender, ethnic orientation, political affiliation, household income, geographic location, and education level, among other identifying characteristics.

All of the eligible survey respondents (n=800) were residents of Knox County. A majority (63%) lived outside the city limits. The average survey respondent was white, 53 years of age, had attended college, and lived in a household in which the total annual income was between $25,000 and $75,000. The average respondent had lived at his or her current resident residence for about 15 years and was more likely to be a Republican than either a Democrat or Independent. The characteristics of the sample are shown in Table 4.2.

Assessment of the representativeness of the sample and the accuracy of the results was performed by comparing the characteristics of the final sample with those of the targeted population. This procedure helps identify any significant differences that might impact the survey findings. Based on the U.S. Census Bureau estimates of the county population, it was expected that the final sample would be overrepresented by males and residents who were older, more educated, and more affluent than non-respondents. These expectations were confirmed upon further analysis (U.S. Bureau of the Census 2011; Survey Sampling International 2005).

Table 4.2. Characteristics of the sample.

Demographics		Frequency (n=800)	Percentage (%)
Gender	Male	428	53.5
	Female	370	46.3
	No Response	2	0.3
Ethnicity	Caucasian (non-Hispanic)	736	92.0
	African-American	29	3.6
	Hispanic or Latino	5	0.6
	American Indian	4	0.5
	Asian or Pacific Islander	6	0.8
	Other	10	1.3
	No Response	10	1.3
Political Affiliation	Conservative Republican	188	23.5
	Moderate Republican	178	22.3
	Independent	141	17.6
	Moderate Democrat	132	16.5
	Liberal Democrat	54	6.8
	Unsure or Undecided	54	6.8
	Other	26	3.3
	No Response	27	3.4
Income	Under $25,000	83	10.4
	$25,000 to $49,999	196	24.5
	$50,000 to $74,999	182	22.8
	$75,000 to $99,999	116	14.5
	Over $100,000	142	17.8
	No Response	81	10.1
Education	Less than High School	18	2.3
	Some High School	18	2.3
	High School Graduate or GED	107	13.4
	Some College/Technical School	235	29.4
	College Graduate	249	31.1
	Graduate School or more	164	20.5
	No Response	9	1.1

Table 4.2. Characteristics of the sample (continued).

Demographics		**Frequency (n=800)**	**Percentage (%)**
Age	20-24	7	0.9
	25-34	87	10.9
	35-44	136	17.0
	45-54	200	25.0
	55-64	167	20.9
	65-74	119	14.9
	75-84	65	8.1
	85 or Older	9	1.1
	No Response	10	1.3
Years Lived in Current Residence	One Year or Less	48	6.0
	1-5 Years	204	25.5
	5-10 Years	150	18.8
	10-15 Years	109	13.6
	15-20 Years	66	8.3
	20-25 Years	40	5.0
	More than 25 Years	179	22.4
	No Response	4	0.5

According to 2004 U.S. Census data, females represented 51.7% of Knox County, and in the current study's sample from 2005, females represented 47.2%. According to SSI's projection of 2000 U.S. Census data to July 2004, residents age 55 or older represented 23.4% of Knox County, and in the current study's sample it was 27.4%. SSI also estimated that incomes above $100,000 represented 12.6% of county households, and in the current study's sample it was 19.7%. According to 2004 U.S. Census data, the proportion of county residents living inside city limits was 46%, while 37% of the current study's respondents were from City households. However, overall assessment of the sample and knowledge of the general literature suggest that the survey results should provide a reasonable depiction of the general views of county residents on tree management issues. Still, interpretations of these results should be considered with respect to measurement error, to coverage error, and to other potentially significant differences in the views of non-respondents.

Theoretical Constructs

The measurement scales used in this study were adapted from the literature and deployed in the survey instrument as described in the previous section. This section presents in detail the indicators of each hypothesized construct: *Experience with Trees and Landscaping* (Experience), *Tree Knowledge* (Knowledge), *Basis of Satisfaction with Trees* (Basis of Satisfaction), *Basis of Attachment to Trees* (Basis of Attachment), and *Support for Local Tree Protection and Maintenance Policies* (Support). It was of interest to check the internal consistency of the hypothesized constructs obtained from the results of this survey prior to factor analysis (this procedure is provided later in this chapter). These procedures and preliminary analyses are also provided in this section. Table 4.3 provides a complete list of scale items selected for use in this study and their sources.

Internal Consistency of Constructs

The reliability of the indicators that are assumed to reflect the study constructs was judged by their internal consistency using Cronbach's alpha coefficients (Cronbach 1951). As an additional check, internal consistency was assessed via a principal components analysis using varimax rotation. A principal component is a linear above the cut-off level of 0.70 (Hair et al. 1998), thereby lending support for the appropriateness of the selected measures for this study's constructs.[10] The final number of indicators for each construct is also shown in Table 4.4. The procedure for obtaining this final number of indicators for each construct is outlined below, followed by a description of how the eligible Knox County homeowners (n=800) responded to the questions making up each construct.

<u>Experience with Trees and Landscaping</u>

A 14-item *Experience* scale estimated the level of experience in landscape and tree maintenance (tree planting, pruning, mulching, home gardening and other landscaping-related activities) among homeowners. Thirteen of these items were answered "yes" or "no." One item was measured on a five point Likert scale, and asked how often the homeowner worked in the

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[10] Hair and others (1998) note that for a construct to be considered as reliable, Cronbach's alpha should exceed 0.7. Although Hatcher (1994) allows a slightly lower value for social science research ($\alpha > 0.6$), the current study uses $\alpha > 0.7$ as a measure of reliability.

Table 4.3. List of scale items for each construct and source.

Variables	Items	Source
Experience with Trees and Landscaping	1. Frequency working in yard growing up (5 pt Likert)(Q1)[1] 2. Planted a tree in the past five years (yes/no) (Q2) 3. Planted flowers, vegetables, herbs, or maintained a home garden (yes/no) (Q3a) 4. Talked to others about gardening, tree care or landscaping (yes/no) (Q3b) 5. Read articles or watched programs about gardening, tree care or landscaping (yes/no) (Q3c) 6. Attended a class or a workshop about gardening, tree care or landscaping (yes/no) (Q3d)[2] 7. Hired someone to maintain my lawn, garden, trees or general landscape (yes/no) (Q3e)[3] 8. Visited an arboretum or nursery (yes/no) (Q3f)[1] 9. Contacted a public agency or official about home gardening, tree care or general landscaping (yes/no) (Q3g)[1] 10. Planted a tree on my property (yes/no) (Q3h) 11. Mulched around a tree on my property (yes/no) (Q3i) 12. Pruned or had work done on a tree on my property (yes/no) (Q3j) 13. Cut down or removed a tree on my property (yes/no) (Q3k)[1] 14. Donated time or money to a gardening, tree or landscape group (yes/no) (Q3l)[2]	Lohr and Pierson-Mims (2005); Ewert et al. (2005); Cottrell (2003)

1. Excluded from the final scale due to insignificant regression weight during confirmatory factor analysis (see page 95).
2. Excluded from the final scale due to excessive skewness and kurtosis (see page 91).
3. Excluded from the final scale due to due to weak loading on the *Basis of Satisfaction* factor during principal component analysis (see page 67).

Table 4.3. List of scale items for each construct and source (continued).

Variables	Items	Source
Tree Knowledge	1. Planting a tree (3 pt Likert) (Q6a) 2. Caring for a tree (3 pt Likert) (Q6b) 3. Trimming a tree (3 pt Likert) (Q6c) 4. Protecting a tree from insects and pests (3 pt Likert) (Q6d) 5. Cutting down a tree (3 pt Likert) (Q6e) 6. Identifying native trees to this area (3 pt Likert) (Q6f) 7. Identifying diseased trees (3 pt Likert) (Q6g) 8. Selecting a suitable tree for your landscape (3 pt Likert) (Q6h) 9. Buying a healthy tree (3 pt Likert) (Q6i)	Fraser (1997); Cottrell (2003); Allen (1997); Despot and Gerhold (2003)
Basis of Satisfaction with Tree Places	1. If you were looking for a new place to live, how important would it be for the property to have trees (4 pt Likert) (Q16)[1] 2. Trees provide shade (3 pt Likert) (Q8a) 3. Trees mark seasonal change (3 pt Likert) (Q8b) 4. Trees increase privacy (3 pt Likert) (Q8c) 5. Trees decrease energy costs (3 pt Likert) (Q8d) 6. Trees slow wind (3 pt Likert) (Q8e) 7. Trees improve air quality (3 pt Likert) (Q8f) 8. Trees reduce street noise (3 pt Likert) (Q8g) 9. Trees provide wildlife habitat (3 pt Likert) (Q8h) 10. Trees produce attractive blooms (3 pt Likert) (Q8i)	Flannigan (2005); Sommer et al., (1990); Allen (1997); Lorenzo et al. (2000); Schroeder and Ruffolo (1996)

1. Excluded from the final scale due to due to weak loading on the *Basis of Satisfaction* factor during principal component analysis (see page 68).

Table 4.3. List of scale items for each construct and source (continued).

Variables	Items	Source
Basis of Attachment to Tree Places	1. Trees have a particular personal, symbolic, or spiritual meaning (3 pt Likert) (Q15) 2. Trees inspire community pride (5 pt Likert) (Q12a) 3. Trees in cities help people to feel calmer (5 pt Likert) (Q12c) 4. Trees should not be planted in business districts because they block store signs (5 pt Likert) (Q12h) [1, 2] 5. Trees enhance property values (5 pt Likert) (Q12i) 6. Road widening projects should include more tree preservation and/or tree planting (5 pt Likert) (Q12k) 7. We need to have more trees in Knox County to cool and clean the air (5 pt Likert) (Q12m)	Allen (1997); Treiman and Gartner (2005); Dwyer et al. (1992); Nowak and Dwyer (2007); Lohr and Pierson-Mims (2005); Balram and Dragicevic (2005); Lorenzo (2000); Schroeder and Ruffolo (1996); Wolf (2005)
Support for Local Tree Protection and Maintenance Policies	1. More city/county funding is needed for planting trees in public areas (such as along streets, in schoolyards, and in parks) (5 pt Likert) (Q18a) 2. It is important for utility districts to enforce proper trimming of street trees and protection of tree roots (5 pt Likert) (Q18b) 3. Our local government is spending enough money on saving or planting trees in Knox County (5 pt Likert) (Q18c)[1] 4. Residential developers should cut down fewer trees when building new subdivisions in Knox County (5 pt Likert) (Q18d) 5. Commercial developers should not be required to protect old trees or plant new trees in Knox County (5 pt Likert) (Q18e) [1] 6. There should be stronger rules about protecting large old trees on private residential property (5 pt Likert) (Q18f)	Treiman and Gartner (2005); Balram and Dragicevic (2005); Lorenzo et al. (2000)

1. To be consistent with the analysis of the other scale items, this scale item was reverse coded for analysis.
2. Excluded from the final scale due to insignificant regression weight during confirmatory factor analysis (see page 104).

Table 4.4. Number of scale items used to form study constructs and associated Cronbach's alpha reliabilities.

Construct	Number of Scale Items (Indicators)	Reliability (Cronbach's alpha)
Experience with Trees and Landscaping	13	0.71
Tree Knowledge	9	0.90
Basis of Satisfaction with Trees	9	0.84
Basis of Attachment to Trees	7	0.75
Support for Tree Protection Policies	6	0.72

garden, cared for trees, or engaged in landscaping while they were growing up ("never" to "very often"). The alpha reliability test for the *Experience* scale yielded a relatively low Cronbach's alpha (α) of 0.69. Construct validity was then checked using a principal components analysis. The pattern of eigenvalues (3.46, 1.40, 1.19, 1.04, and 1.02) suggested that the indicators could load on to one factor, but not as strongly as the other constructs discussed below. Of the 14 items, one item, Q3e ("Hired someone to maintain my lawn, garden, trees or general landscape"), was found to load very weakly on the first rotated factor (-0.01) while the loadings of the remaining items ranged from 0.294 to 0.640. Therefore, item Q3e was dropped and α was recalculated to be 0.71 for the modified construct. This value of α was considered to be more acceptable since it exceeded Hair and others (1998) rule of thumb value of 0.7 as a measure of reliability, thus providing reasonable evidence that the scale items measure the underlying construct of *Experience*. Therefore, the *Experience* scale subjected to further analysis was limited to the remaining 13 items.

Tree Knowledge

A 9-item *Knowledge* scale was used to determine the level of perceived knowledge ("very knowledgeable" to "little or [no knowledge]") about tree maintenance and protection (e.g., how to plant, care, and prune a tree, identifying diseased trees, buying a healthy tree) among homeowners. The alpha reliability test for the *Knowledge* scale yielded a Cronbach's alpha of 0.90, thus providing reasonable evidence that the scale items measure the underlying construct of *Knowledge*. Construct validity was then checked using a principal components analysis. The pattern of eigenvalues (5.03, followed by values of 0.83 and less) suggested the presence of one major factor, and the loadings of the 9 items on this rotated factor ranged from 0.615 to 0.837. *Tree Knowledge* was therefore assessed with all 9 items.

Basis of Satisfaction with Trees

A *Basis of Satisfaction* scale was used to determine homeowner beliefs about the importance of various aspects of trees. Nine questions from the 10-item scale asked about various environmental benefits associated with trees (i.e., improving air quality; reducing noise, wind, and energy costs; providing shade, wildlife habitats and privacy). These were measured on a three point Likert scale ranging from “not important” to “very important.” Another question asked how important it was for the homeowner to have trees in their yard if they had to relocate, and was measured on a four point Likert scale of “not at all important” to “very important.” The alpha reliability test for the *Basis of Satisfaction* scale yielded a Cronbach’s alpha of 0.83, thus providing reasonable evidence that the scale items measure the underlying construct of *Basis of Satisfaction*. Construct validity was then checked using a principal components analysis. The pattern of eigenvalues (4.08, 1.12, followed by values of 0.91 and less) suggested the presence of one major factor. Of the 10 items, one item, Q16 (“If you were looking for a new place to live, how important would it be for the property to have trees”) was found to load very weakly on the first rotated factor (0.04) while the loadings of the remaining items ranged from 0.156 to 0.809. This provided evidence that Q16 did not measure the underlying construct of *Basis of Satisfaction* as well as the other scale items. Therefore, item Q16 was dropped and the Cronbach’s alpha for the modified construct was recalculated to be 0.84. This value of α provided reasonable evidence that the remaining nine scale items measure the underlying construct of *Basis of Satisfaction*. Therefore, the *Basis of Satisfaction* scale subjected to further analysis was limited to the remaining 9 items.

Basis of Attachment to Trees

Basis of Attachment towards trees was measured with a 7-item scale. Six questions on the 7-item scale asked homeowners about their level of agreement or disagreement with statements that were designed to measure attitudes about urban trees (i.e., “Trees inspire community pride” and “Trees enhance property values”). These were measured on a five point Likert scale ranging from “strongly disagree” to “strongly agree.” One question (Q12h), which asked the respondent his/her level of agreement with “trees should not be planted in business districts because they block store signs,” was recoded to reflect a positive attitude toward trees in business districts. Another question (Q15) asked if trees had a personal, symbolic, or spiritual meaning to the respondent, and was measured on a three point Likert scale consisting of "no," "unsure," and "yes." The alpha reliability test for the *Basis of Attachment* scale yielded a Cronbach's alpha of 0.75, thus providing reasonable evidence that the scale items measure the underlying construct of *Basis of Satisfaction*. Construct validity was then checked using a principal components analysis. The pattern of eigenvalues (2.55 followed by 0.93 and less) suggested the presence of one major factor, and the loadings of the seven items on this rotated factor ranged from 0.506 to 0.738. *Basis of Attachment* was therefore assessed with all 7 items.

<u>Public Support for Local Tree Protection and Maintenance Policies</u>

Homeowner *Support* was measured with a 6-item scale. The questions associated with *Support* asked homeowners to estimate their level of agreement on a five point Likert scale ranging from "strongly disagree" to "strongly agree" with statements that were supportive of more local government funding for planting public trees, placing restrictions on tree-cutting by residential developers, and placing more protective measures on mature trees located on private residential property. Two questions asked subjects to estimate their opposition to local government spending on protecting trees (Q18c) and opposition to requiring commercial developers to protect and plant trees (Q18e). These two questions were recoded to reflect public support. The alpha reliability test for the *Support* scale yielded a Cronbach's alpha of 0.72, thus providing reasonable evidence that the scale items measure the underlying construct of *Support*. Construct validity was then checked using a principal components analysis. The pattern of eigenvalues (2.5 followed by 0.92 and less) suggested the presence of one major factor, and the loadings of the 6 items on this rotated factor ranged from 0.522 to 0.750. Therefore, the *Support* scale subjected to further analysis included all 6 items.

Spatial Analysis Procedures

The theoretical model presented earlier in Figure 3.3 suggests that urban tree canopy density (*Canopy Density*) is positively related to both basis of place attachment to the urban forest (*Basis of Attachment*) and basis of place satisfaction with the urban forest (*Basis of Satisfaction*). Together, these three variables represent *Sense of Place* (SOP) with regard to tree places. This section outlines how SOP is operationalized to inform the current study's methodology and the GIS procedures used to capture biophysical data for integration with the social data.

Contribution of Biophysical Indicators to Sense of Place

According to Stedman's (2003a) conceptualization of SOP, landscape features such as trees do not contribute directly to SOP but are mediated by symbolic meanings of the landscape that produce *Sense of Place*. In his research of Wisconsin lakeshore homeowners, elements of the natural environment (e.g., shoreline housing density as measured by structures per mile, lake color, and lake turbidity) underpin the socially-constructed symbolic landscape meanings on which SOP is based. These symbolic meanings are represented as "basis of attachment" and "basis of satisfaction" in the format of a "meaning-mediated model" (see Figure 4.1).

In the current research, urban tree *Canopy Density* was selected to be the landscape-specific attribute (i.e., the "biophysical" variable), and is based on Stedman's findings that the two SOP dimensions (place attachment and place satisfaction) are directly related to "place meanings" (basis of attachment and basis of satisfaction), which in turn are functions of place setting characteristics. Although "place attachment" and "place satisfaction" were not directly measured

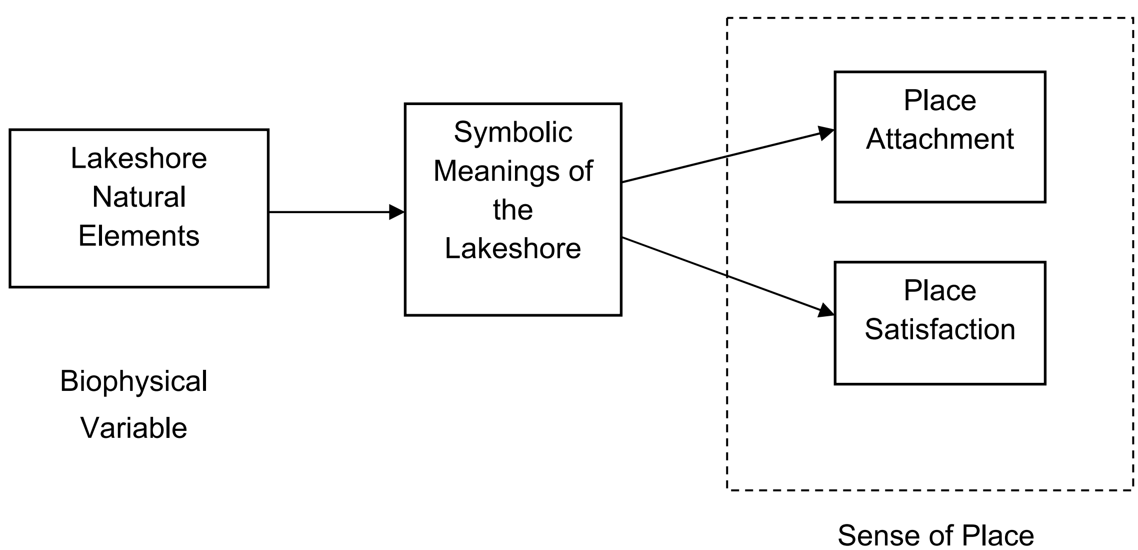

Figure 4.1. Stedman's conceptualization of S*ense of Place* as used in his 2003 study.

as in Stedman's work, I posit that "tree place attachment" and "tree place satisfaction" may be similarly represented by the relationship shown in Figure 4.2.

To review, the current study's *Basis of Attachment* measures are statements which imply "place meanings" such as "trees create a belonging place," "trees create a healthier place," and "trees create a wealthier place" (see Table 4.5). Respondents were asked to rate their level of agreement with these indicators of the construct *Basis of Attachment.* Theoretically speaking, this study assumes that respondents who agree with these place meanings, and also live in an area with trees, would exhibit "tree place attachment." Ultimately, this would translate into greater support for tree protection policies. In turn, *Canopy Density* is indirectly, and positively, related to *Support.*

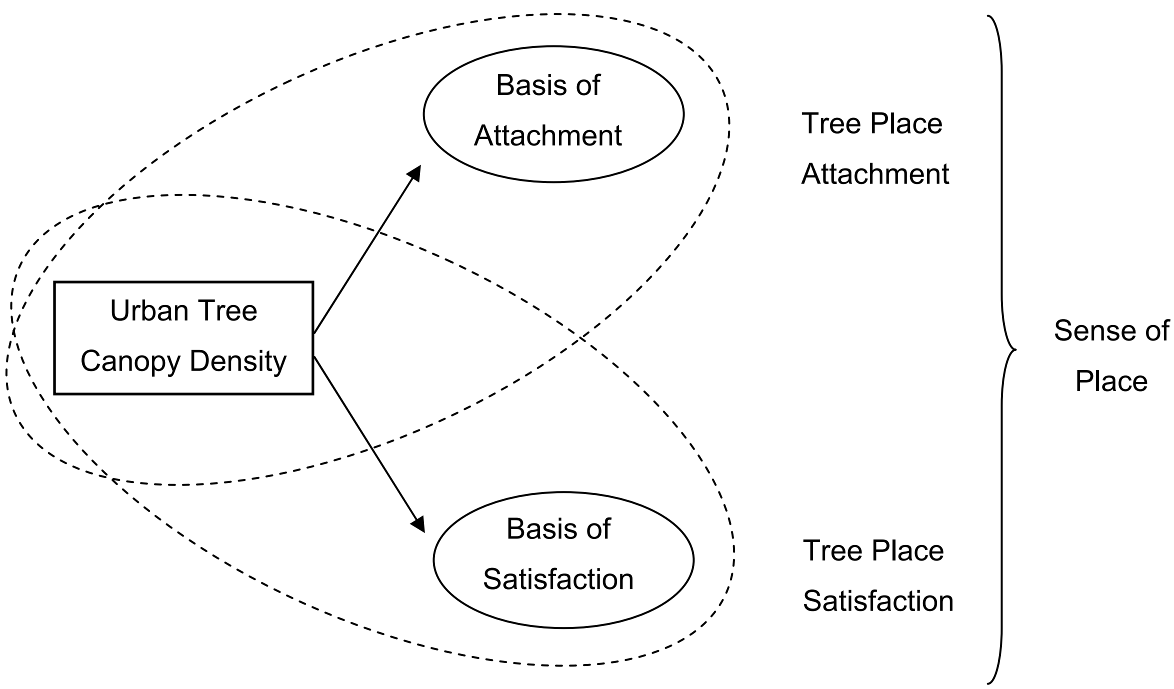

Figure 4.2. *Sense of Place* as conceptualized by *Tree Place Attachment* and *Tree Place Satisfaction* in this current study.

Table 4.5. Conceptualization of place meanings based on survey items measuring *Basis of Attachment*.

Basis of Attachment indicator	Place meaning implied by *Basis of Attachment* indicator
Q15. Trees have a particular personal, symbolic, or spiritual meaning	Trees contribute to the spirituality of a place
Q12a. Trees inspire community pride	Trees are part of a place that I am proud of
Q12c. Trees in cities help people to feel calmer	Trees create a calming place
Q12h. Trees should not be planted in business districts because they block store signs (recoded)	Trees are part of a place where I like to shop
Q12i. Trees enhance property values	Trees create a wealthier place
Q12k. Road widening projects should include more tree preservation and/or tree planting	Trees are part of a place where I like to drive my car
Q12m. We need to have more trees in Knox County to cool and clean the air	Trees create a healthier place

Similarly, the current study's *Basis of Satisfaction* measures are statements about attributes of trees and respondents are asked to rate how important these characteristics are to them, such as "trees provide shade" and "trees mark seasonal change" (see Table 4.3). Theoretically, the hypothesized model assumes that people who assign more importance to various tree attributes and who live in areas with more trees would have greater satisfaction with their home place. Greater "tree place satisfaction" is then hypothesized to be positively related to support for tree protection policies. In this way, *Canopy Density* has an indirect positive effect on *Support*, as mediated by *Basis of Satisfaction*.

Calculation of Buffer Zone

The socio-psychological literature reviewed in Chapter 2 suggested that urban trees in one's "place" may be associated with a heightened *Sense of Place*. Although the scale of what constitutes a homeowner's "place" is subjective and debatable (Galster 1986), delineation of geographic boundaries was necessary to test the current study's model. In order to do so, it was first necessary to geocode each survey respondent's location. This was performed using publicly-available GIS data provided by Knoxville/Knox County Geographic Information Systems (KGIS). ArcGIS 9.0 ArcMap Version 9.3.1 (ArcGIS) was used to store and analyze the geographic information. Geocoding was performed by matching the residential location of survey respondents to those in the KGIS database. A map was generated from the latitude and longitude of each respondent's street address, and a unique survey identification number common to each mapped location and the corresponding survey case was used to cross-reference the geocoded data. Every point representing the latitude/longitude of the 800 addresses was relocated to the center of each property parcel using the ArcGIS function *Feature to Point* that analyzed the polygon representing each parcel, and then returned a point halfway between the polygon's minimum and maximum X and Y extents. Each of the geocoded locations represented the position from which an objective environment measure of tree canopy density would be extended, in the form of varying radii that formed circles around each parcel.

In the current research, I draw on the methodologies used in hedonic modeling which measure the impact of landscape features on property values. Similar to hedonic models that measure the relationship between vegetative cover and distance variables (e.g., distance to parks) and housing values, it was necessary to delineate a "zone" around each homeowner's property for measurement of the biophysical parameter, urban tree *Canopy Density*. There is not much guidance in the landscape preference or place attachment literature for what constitutes a proper "visual zone," but literature in hedonic property value analysis, planning, and epidemiology use distances ranging from a ¼ mile distance buffer based on "walkable" neighborhoods up to a distance of 1 mile – the circles formed by this range of radii are likely to be defined by homeowners as the "neighborhood" (Wood, Frank, and Giles-Corti 2010, Geoghegan, Wainger, and Bockstael 1997, Acharya and Bennett 2001, Hoehner et al. 2005).

Two studies by Mansfield and others (2005) and Orford (2002) provide greater detail for conceptualizing "buffer zones" that are applicable to the current study.[11] Mansfield and others used hedonic property value logic to explain how different interpretations of forest greenness are valued (in a monetary sense) by people. They tested the hypothesis that the contribution of trees to an individual property values or in the neighborhood around that property resonates through a specific buffer zone. They compared buffer zones with radii of 0-400 meters, 400-800 meters, and 800-1600 meters. In another hedonic house price study by Orford (2002), "street

[11] In proximity analysis, a buffer zone is a map "window" which represents an area a set distance from the original object of interest.

level locational attributes" such as parks and schools were measured at distances of 50, 100, and 200 meters from the property, but he concluded that the effect of "street quality" beyond 100 meters was generally negligible.

In order to capture a visual zone around each house that would include the yard and perhaps the immediate neighbors, a range of radii was used in this study to create buffer zones as circles drawn around each homeowner's property. The radius of each circle was drawn from the centroid of the homeowner's parcel, which was geocoded as described above. Since it was of most interest to capture the area visible from the parcel (considering that a number of parcels in Knox County are not located in "walkable" neighborhoods), tree canopy density was measured for buffer zones with radii of 100, 250, 500, and 1,000 feet, using the procedure described below.

Use of LiDAR to Calculate Tree Canopy Density

KGIS also provided the Light Detection and Ranging (LiDAR) data that represents the presence of tree canopy. LiDAR allows the direct measurement of three-dimensional structures and the underlying terrain, and is used for the generation of topographical maps for agriculture, meteorology applications (e.g., studies of atmospheric composition), and mine detection in the military (Wikipedia contributors 2011). Most importantly, foresters use LiDAR to understand the forest canopy and terrain, assess forest health, calculate forest biomass, classify terrain, identify drainage patterns, and plan forest management activities such as fertilization and harvesting programs (ESRI 2010). Similar to radar technology which uses radio waves, LiDAR detects and measures the distance to an object is by measuring the time delay between transmission of a pulse and detection of the reflected signal. Instead of radio waves, LiDAR uses much shorter wavelengths of the electromagnetic spectrum, typically in the ultraviolet, visible, or near-infrared range.

LiDAR data is characterized by an extremely high resolution, and takes the form of very dense collections of points over an area, known as "point clouds." Such high resolution gives higher accuracy for the measurement of the height of features on the ground and above the ground. The ability to capture the height of objects (such as trees) at such high resolution is LiDAR's principal advantage over conventional optical instruments (e.g., digital cameras) for elevation model creation. The LiDAR data for West Knox County was flown in 2007 to 2.7' point spacing.

East Knox County LiDAR data was obtained in 2010, also to 2.7’ point spacing. This data provided canopy height information for trees at least 20’ tall.

Since a single LiDAR file contains millions of points, management of the data is facilitated by loading the points into the geodatabase feature type known as “multipoint.” This was done using the 3D Analyst toolset included in ArcGIS, which contains the tool *LAS To Multipoint*.[12] LAS[13] files captured since July 2009 conform to the LAS 1.3 specification, which allows the separation of LiDAR data into ground returns and non-ground returns characterized by a system that uses nine classification codes (see Table 4.6). When LiDAR data is provided to a client, the classifications would normally be provided as part of the delivered documentation. The ground returns can generate a detailed terrain of the area of interest, while the tree canopy returns can be filtered to provide urban forest structure at the desired height. For example, classification value 5 is “high vegetation,” which is separate from classification value 3 for “low vegetation,” classification value 4 for “medium vegetation” and classification 6 for “building.” When the LAS data files are read by the *LAS to Multipoint* tool available in ArcGIS, it can accommodate these

Table 4.6. LiDAR classifications (ESRI 2010).

Classification Value	Description
1	Unclassified
2	Ground
3	Low Vegetation
4	Medium Vegetation
5	High Vegetation
6	Building
7	Low Point (noise)
8	Model Key Point (mass point)
9	Water

[12] KGIS staff assisted in this study with the conversion of the LiDAR data into a usable format.

[13] The raw LiDAR dataset is stored in LAS file format, which is the industry standard proposed by the American Society for Photogrammetry & Remote Sensing (ASPRS) LiDAR Subcommittee (ASPRS 2010).

classifications and separate them into unique feature classes of interest. Since the goal of this study was to assess tree canopy surface, the Input Class Code was specified as “5,” corresponding to “High Vegetation” as shown in Table 4.6.

After loading the LiDAR points into multipoint format, digital elevation model (DEM) and digital surface model (DSM) raster files were built directly from the multipoint feature class using the *Point to Raster* tool. Raster files are useful in proximity analysis because they provide data as a pixel (“cell”) grid of rows and columns. This simple grid structure is easier to analyze than the LiDAR point clouds due to a raster file’s single value cell structure that is amenable to relatively simple software programming (Galati 2006). A DSM is a first return of the pulse transmission which captures tree canopy and buildings, and a DEM contains bare earth or ground returns. The LiDAR data was processed to create raster elevation files using Tagged Image File Format, commonly known as “TIFF files” (*.tif).

After generating the raster files from the LiDAR data, the canopy density was then estimated. ArcGIS Spatial Analyst was used to count all “no data” (NoData) cells in the TIFF file showing the tree canopy, and then assign a value of zero to these cells. The raster file was then post-processed with the *Spatial Analyst Raster Calculator* tool. Using the *Conditional* evaluation function (“Con tool”), each cell in the raster file was evaluated for the NoData value of zero. If a non-zero value was encountered, the tool pulled the value from the original raster file. This resulted in a final raster file without zero values, only showing “high vegetation” (tops of trees at 20’ elevation or greater).

Finally, the *Clip* tool was used to extract high vegetation raster for buffer zones with radii of 100’, 250’, 500’, and 1,000’. A “buffer” in ArcGIS refers to construction of area features by extending outward from point, line, or polygon features over a specified distance. In this study, the *Buffer* tool in the *Proximity* toolset was used to specify the creation of the circular buffers around the centroid of each parcel. Figure 4.3 shows the processed high vegetation raster overlaying an aerial photograph of a small portion of Knox County that has been geometrically corrected ("orthorectified") such that the scale is uniform, and with the buffer zones clipped. The percent of each buffer covered by high vegetation was calculated using the following formula:

Figure 4.3. Example buffer zones for three survey cases used in the study (radius = 250 feet).

Percent tree canopy = tree canopy area (SF) / buffer area (SF) * 100

The survey data was then ‘‘joined’’ to the tree density data using a unique survey identification number common to both the map and survey cases.

Overview of Structural Equation Modeling Procedures

The research model and the proposed hypotheses presented in Chapter 3 were tested using structural equation modeling (SEM). SEM is a comprehensive statistical approach for testing hypotheses about relationships among observed and latent variables, and is useful because of its ability to correct for measurement error, account for indirect effects through mediating variables, and directly test "fit" of a proposed model to observed data. The biggest advantage of using SEM over regression analysis is that regression equations are essentially predictive and correspond to conditioning on observations of explanatory variables without manipulation—actual or theoretical. SEM can simultaneously estimate all hypothesized path coefficients and test each causal path for its significance (Bentler and Bonett 1980). The observed variables in this study are the responses to the survey questions ("scale items" or "indicators"), and the latent variables (also called "constructs," "factors," and "dimensions") are the unobserved variables implied by the covariances among the indicators making up each hypothetical construct discussed in Chapter 2. A major objective of SEM is to estimate the values of directional and non-directional associations (regression coefficients and covariances, respectively) among a set of measured and latent variables that are postulated in the hypothesized model.

Data were analyzed using PASW® Statistics 18.0 (PASW), which evolved from the earlier statistical package SPSS® 13.0 (in which the data were originally entered) and Amos™ 18.0 (Amos™). The models tested were covariance structures. The latent constructs were "Life Experience with Trees and Landscaping" or *Experience,* "Tree Knowledge" or *Knowledge*, "Basis of Attachment to Trees" or *Basis of Attachment*, "Basis of Satisfaction with Trees" or *Basis of Satisfaction*, and "Support for Tree Policies" or *Support.* Each had multiple indicators presented in Table 4.3.

The SEM analysis followed a two-step procedure using Amos™, based in part on an approach recommended by Anderson and Gerbing (1988). This is a sequential testing procedure based on the recognition that the structural model is nested within the measurement model. In Step 1, confirmatory factor analysis (CFA) was performed to develop a measurement model that identified whether the observed variables reliably reflected the hypothesized latent variables *Experience, Knowledge, Basis of Attachment, Basis of Satisfaction*, and *Support* using the covariance matrix. Construct validity was determined by examining how well measurement items factored into the theoretically predicted dimensions (represented by the latent variables) using CFA techniques that demonstrate convergent validity (variables hypothesized as related to the construct should be positively correlated) and discriminant validity (variables hypothesized as unrelated would be uncorrelated). The calculation of latent variable convergent and discriminant reliability is necessary in order to create a sound measurement model, an important prerequisite for Step 2, which analyzed a structural regression (SR) model absed on the theoretical model specified in Chapter 3.

To summarize, eight structural models were run as part of the two steps:

- **Step 1** employed CFA to assess fit for each of the five models representing each of the constructs separately, followed by CFA of the total measurement model where all five latent variables were allowed to intercorrelate freely with one another (i.e., non-directional associations), and
- **Step 2** modified the measurement model to represent the study hypotheses, beginning with a SR model showing the regression structure (i.e., directional associations) among the latent variables only, followed by a SR model with latent variables and the tree density manifest variable (to define *Sense of Place*).

The consideration of eight separate models allowed the examination of the relative contributions of each set of variables to improve model fit. In each model, maximum likelihood estimation was used to generate the fit statistics that were to be minimized; these criteria represent the discrepancy between the sample (observed) covariance matrix and the covariance matrix predicted by the hypothesized model as represented by the "residual matrix." Ideally, the elements of the residual matrix should approach zero, as in the case where the hypothesized model closely approximates the relationships among the sample data.

Testing of Model Fit

The structural equation modeling literature suggests multiple ways to determine fit, which is provided by Amos™ output. The most widely reported goodness-of-fit index used in for testing adequacy of models in SEM is the chi-square ($\chi2$) test, which is an overall measure of how much the implied covariances differ from the sample covariances. In general, the more the implied covariances differ from the sample covariances, the bigger the chi-square statistic will be. In contrast to traditional statistical procedures, analysis of fit using the $\chi2$ test is a "badness-of-fit" measure in the sense that a small χ2 reflects a good fit and a large χ2 a bad fit. This logic is backwards from the usual "reject-support" context for statistical tests. The χ2 test uses the "accept-support" context where the null hypothesis (H_0) represents the researcher's beliefs, or in this case where the model is consistent with the data matrix. H_0 postulates that specification of the factor loadings (lambda weights), factor variances and covariances, and error variances for the model under study are *valid*; the χ2 statistic provides the test that H_0 is true. This means that a statistically significant result (e.g., $p < 0.05$) indicates a problematic model-data correspondence. If H_0 is correct, χ2 should be small, and the *p* value associated with χ2 should be > 0.05 (indicating an insignificant χ2) (Bollen 1989, Kline 2011). Steiger (2007) notes also that "accept-support" tests are logically weak because lack of evidence to disprove an assertion (H_0) does not prove the assertion is true.

However, the chi-square test statistic has considerable power to detect the slightest deviation from 'perfect fit'. Since this test is based on the assumption that the model holds exactly in the population, employing it may be unrealistic in behavioral sciences research. This is because social scientists generally expect that a model should closely approximate some phenomenon, but not perfectly reproduce it. A consequence of the exact-fit assumption is that a model – even if it gives an approximately true description of the population – may be rejected due to the sensitivity of this test to multivariate non-normality, correlations of observed variables, variables with high proportions of unique variance, and sample sizes greater than 300 cases. Hence, rather than focusing on the statistical significance of the χ2 statistic, it has been suggested to look at the "chi-square to degrees of freedom ratio" and a number of other fit indices that have been developed to supplement the χ2 statistic when testing hypotheses in covariance structure modeling, as well as other unique approaches to the model-fitting process (Byrne 2010, Kline 2011). The results of CFA and SR model analyses in this study will include a report of the χ2 statistic and the degrees of freedom (*df*), but the reader should keep in mind these important caveats.

In this study, four other fit indices were employed in addition to χ2: the ratio of chi-square to degrees of freedom (χ2/*df*), the comparative fit index (CFI), the goodness-of-fit index (GFI), and the root mean square error of approximation (RMSEA) (Jöreskog and Sörbom 1993, Byrne

2010). The χ2/*df* statistic is obtained by dividing the χ2 by the model's degrees of freedom.[14] This measure takes into account the model's complexity. A χ2/*df* ratio less than 5:1 indicates an acceptable fit (Marsh and Hocevar 1985). Values for the CFI range from zero to 1.00 and represent the improvement of fit of the specified model over a baseline model (the "independence model") in which all variables are constrained to be uncorrelated; a cutoff value close to 0.95 is recommended as an indicator of goodness-of-fit (Hu and Bentler 1998, Byrne 2010). The RMSEA is often employed when there is a large sample size, as in this study where n=800. It attempts to correct for the tendency of the χ2 to reject any model specified when the sample is large, thus testing "badness" of fit. The RMSEA indicates a good fit if it is less than 0.08 (McDonald and Ho 2002). The Jöreskog-Sörbom GFI is an absolute fit index that estimates the proportion of covariances in the sample data matrix explained by the model, and indicates how much better the hypothesized model fits compared with no model at all (Jöreskog 2004 in Kline 2010). GFI values close to 1.00 indicate a good fit; values in excess of 0.90 indicate an acceptable fit (Bentler 1990, Bollen 1989). Garson (2010) recommends assessing model fit of both measurement and structural models using the χ2 test statistic, RMSEA, and at least one of the baseline fit measures (e.g., CFI and GFI). In this study, χ2/*df*, CFI, and RMSEA are considered to be primary model fit criteria, while GFI is considered to be a secondary fit statistic. The χ2 test statistic is also reported for comparison purposes.

Model Improvement

Standardized regression weights, correlation residuals (also called standardized covariance residuals), standardized residuals, and modification indices (MIs) were examined to identify potential parameters that should be added or deleted to improve the fit of the model; "parameters" include not only manifest and latent variables, but also covariances and regression paths. Only those parameters that improved the model's fit while making conceptual sense were added or deleted. A standardized regression weight below 0.4 was considered to be unacceptable due to the risk of measurement errors (Hair et al. 1998). A correlation residual is the difference between a model-implied correlation and an observed (sample) correlation; absolute values > 0.10 suggest the model does not explain the corresponding sample

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[14] The degrees of freedom (*df*) are determined by subtracting the number of parameters estimated from the number of known parameters. The goal is to have an "overidentified" model with a positive *df* value, so goodness of fit may be evaluated.

correlation very well. In general, correlation residuals were considered to be more important indicators of fit than the model fit indices discussed above (Kline 2010). The standardized residual is the ratio of a covariance residual over its standard error (Jöreskog and Sörbom 1993). Although values below 2.58 are usually considered to be desirable (indicating statistically insignificant differences in the theoretical model and the observed data), this test is more sensitive to sample size than the interpretation of correlation residuals. Therefore, as recommended by Byrne (2010) and Brown (2006), data were examined for outliers when interpreting the salience of this aspect of model fit diagnostics. MIs indicate the amount the overall $\chi 2$ value would be reduced by "freeing" (estimating) any single particular path that is not currently estimated. Amos™ provides as output the "estimated parameter change" (EPC) with the MI, which predicts the amount a fixed parameter would change should the model be reparameterized in response to the MI recommendations to obtain a better model fit. Excessively high MIs (e.g., >20) are considered to be signs of misfit, but this study employed the strategy recommended in the literature to use outlying MI values as indicators of potentially problematic model parameters instead of a hard cutoff value (Byrne 2010). Any model modifications suggested by MIs, residuals, or other goodness-of-fit indices were carefully considered in order to ensure that parameter changes (e.g., eliminating measurement items or adding covariances) were theoretically substantiated. Figures 4.4 and 4.5 show flow diagrams for the methodological process in Step 1 and Step 2 of the SEM two-step procedure, respectively.

Missing Data

As discussed earlier in this chapter, 38 cases were removed due to the respondent not answering 20 questions or more. As a result of this culling of the cases with a high number of non-responses, all of the variables used in this analysis contained 5.0% missing values or fewer, which is of little concern when analyzing n=800 cases (Kline 2010). Thirty-seven (37) of the 54 variables contained less than 1.0% missing values. Although Amos™ will produce estimates from datasets containing missing values using maximum likelihood, the output does not include modification indices or tests for normality. Therefore, prior to analysis, missing data were replaced by using the expectation maximization (EM) algorithm in PASW, which produces asymptotically unbiased estimates (Hippel 2004).

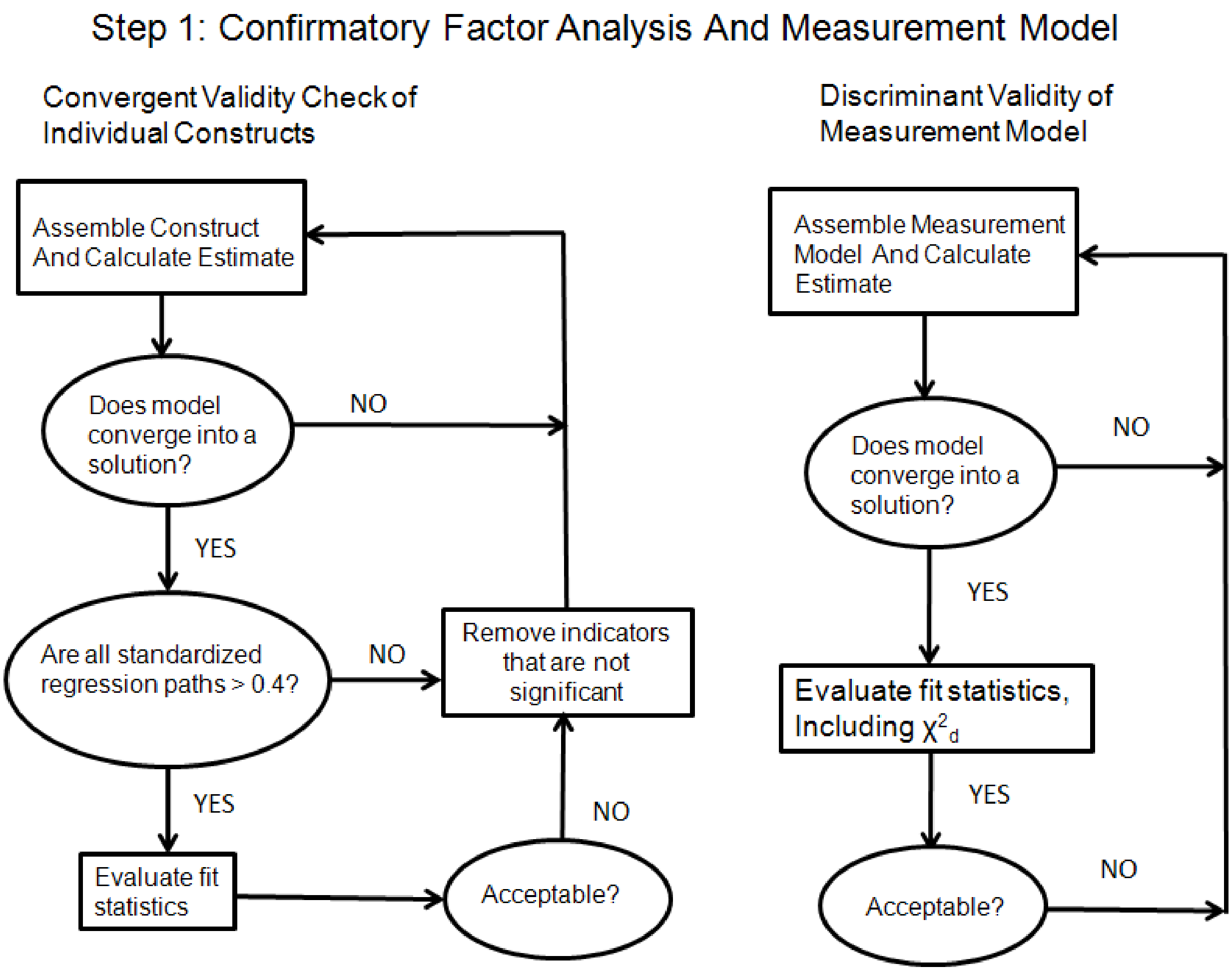

Figure 4.4. Step 1 of the SEM two-step procedure.

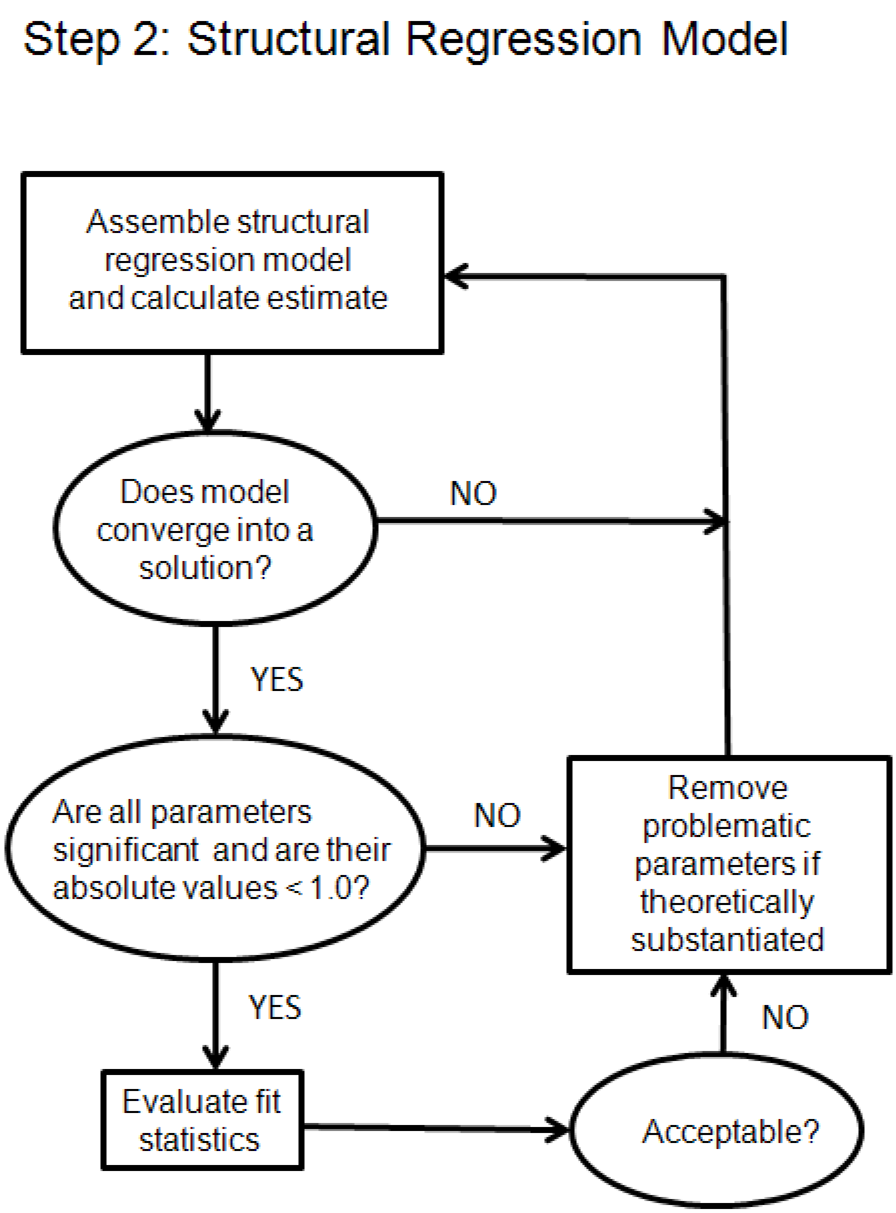

Figure 4.5. Step 2 of the SEM two-step procedure.

Considerations of Normality and Continuous vs. Categorical Variables

Maximum likelihood estimation in SEM requires the assumption of multivariate normality. However, as Micceri (1989) suggested, much social and behavioral science data may fail to satisfy this assumption (McDonald and Ho 2002). A number of simulation studies (Chou et al. 1991, Hu and Bentler 1998, West et al. 1995) suggest that maximum likelihood estimation can give biased standard errors and incorrect test statistics in the presence of excessive skewness and/or kurtosis in the data, although other studies examining the robustness of the multivariate normality assumption have shown that parameter estimates remain valid under reasonable assumptions even when the data are nonnormal (Chou et al. 1991, Hu and Bentler 1995, West et al. 1995). Many instances of multivariate normality are detectable through inspection of univariate distributions. Therefore, the multivariate normality assumption was evaluated univariately using Mardia's (1970) skewness and kurtosis coefficients. West and others (1995) recommend that skewness < 2 and kurtosis < 7, with kurtosis being a greater concern than skewness.

Categorical variables are those with two values (i.e., binary, dichotomous) or those with a few ordered categories, while ordinal variables are variables with many categories, such as 7-point Likert-type scales. The survey instrument used in this study had a maximum of 5-point Likert scales, in addition to dichotomous responses ("yes" or "no") and 3-point and 4-point Likert scales. Although Kline (2011) suggests that 15-point and greater Likert scales are necessary to meet stringent normality requirements, response rate and clarity of the questions were both major considerations which resulted in the selection of the smaller scales in the study's survey design. Some researchers recommend the use of polychoric and tetrachoric correlations for ordinal and binary data, respectively, since the Pearson correlation could slightly underestimate the degree of association between variables and result in reduced factor loadings during CFA (DiStefano 2002). However, analytical and empirical work have also demonstrated that simply substituting a matrix of polychoric/tetrachoric correlations for the sample product–moment covariance matrix in the usual maximum likelihood estimation function for SEM is inappropriate (Flora and Curran 2004). Although this approach will generally yield consistent parameter estimates, it is known to produce incorrect test statistics and standard errors. Byrne (2010) suggests that the literature to date would appear to support the notion that as the number of categories increases in a categorical variable, $\chi 2$ is less affected; and "continuous methods can be used with little worry when a variable has four or more categories" (Bentler and Chou 1987 in

Byrne 2010:148). Also, if the data approximate a normal distribution, failure to address the ordinality of the data is likely negligible in SEM (Atkinson 1988, Babakus et al. 1987, Muthén and Kaplan 1985). This is because multiple manifest variables using a Likert scale response are tapped into points along a continuum of responses making up the underlying construct; even though the data of individual indicator variables may not be continuously distributed, the distribution of the abstract phenomenon that is being indirectly represented by the construct is continuous (University of Texas 2001). Therefore, the data in this study were treated as interval scales and examined for skewness and kurtosis as an assessment of normality. The raw data was then entered into Amos™, which calculated covariance matrices using the Pearson correlation.

Summary

This chapter on research methods described the research strategy, and provided information required to test the research model and hypotheses. The first section of this chapter dealt with data collection procedures using the survey instrument. Criteria used to extract statistically relevant samples from the raw data supplied by SSI (randomly selected Knox County mailing addresses) were described, as well as quality control procedures used to maximize the potential for obtaining a representative sample from the survey for the purposes of this study. The second section presented characteristics of the collected survey sample, including a description of the study area, socio-demographic information about the survey respondents, and representativeness of Knox County residents. The third section presented descriptions and literature sources of the selected scale items used to measure the hypothesized constructs, and preliminary analyses of the constructs using Cronbach's alpha and principal component analysis. As a result of weak factor loading during the principal component analysis, two scale items were eliminated from further analysis: Q3e ("If you were looking for a new place to live, how important would it be for the property to have trees") in the *Experience* construct and Q16 ("If you were looking for a new place to live, how important would it be for the property to have trees") in the *Basis of Satisfaction* construct. Reliabilities of the scale items used to form the study constructs were all above the cut-off criteria of 0.70. The fourth section outlined spatial analyses procedures, and provided context in which these biophysical measurements would be incorporated in the study's hypothesized *Sense of Place* constructs. The chapter concluded with an overview of the structural equation modeling procedures used to test the hypothesized model.

CHAPTER V

DATA ANALYSIS AND HYPOTHESIS TESTING

Data analyses and the results of hypothesis testing are presented in this chapter. Data were analyzed using PASW® Statistics 18.0 (PASW) and Amos™ 18.0 (Amos™), and the models tested were covariance structural models with multiple indicators for all the latent constructs. The present analysis followed a two-step approach based in part on an approach recommended by Anderson and Gerbing (1988). It is called a "two-step" approach because the measurement model first is developed and evaluated separately from the full structural equation model that simultaneously models measurement and structural relations. The measurement model in conjunction with the structural model makes possible a comprehensive confirmatory assessment of construct validity (Bentler 1978). In Step 1, confirmatory factor analysis (CFA) was used to develop a measurement model that demonstrated an acceptable fit to the data. In Step 2, the measurement model was modified so that it came to represent the theoretical model of interest presented in Figure 3.1. This theoretical model was then tested and revised until a theoretically meaningful and statistically acceptable model was found.

The first section presents preliminary analyses prior to conducting structural equation modeling (SEM). The second section presents the results of CFA of the individual constructs and the measurement model (Step 1), including tests of reliability, validity, and fit statistics. The third and final section provides the results of structural model evaluation and hypotheses testing (Step 2).

Preliminary Analyses

The first step in analyzing the data was to generate the descriptive statistics of the responses obtained from the data. PASW® Statistics 18.0 (PASW) was used to calculate these descriptive statistics of the measurement items making up each construct. The minimum values, maximum values, means, and standard deviations of each measurement item were calculated, and are presented in Table 5.1.

Table 5.1. Descriptive statistics of scale items.

Construct	Scale Items	Range	Mean	Standard Deviation	Skewness	Kurtosis
Experience with Trees and Landscaping	Q1: Frequency working in yard growing up	1-5	3.58	1.06	-0.47	-0.38
	Q2: Planted a tree in the past five years	1-2	1.67	0.47	-0.73	-1.47
	Q3a: Planted flowers, vegetables, herbs, or maintained a home garden	1-2	1.91	0.28	-2.90	6.41
	Q3b: Talked to others about gardening, tree care or landscaping	1-2	1.87	0.38	-1.71	0.94
	Q3c: Read articles or watched programs about gardening, tree care or landscaping	1-2	1.77	0.42	-0.13	-0.31
	Q3d: Attended a class or a workshop about gardening, tree care or landscaping	1-2	1.06	0.23	3.86	12.92
	Q3e: Hired someone to maintain my lawn, garden, trees or general landscape*	1-2	1.38	0.48	0.51	-1.75
	Q3f: Visited an arboretum or nursery	1-2	1.55	0.50	-0.22	-1.96
	Q3g: Contacted a public agency or official about home gardening, tree care or general landscaping	1-2	1.12	0.32	2.40	3.76
	Q3h: Planted a tree on my property	1-2	1.52	0.50	-0.09	-2.00
	Q3i: Mulched around a tree on my property	1-2	1.71	0.45	-0.95	-1.11
	Q3j: Pruned or had work done on a tree on my property	1-2	1.76	0.43	-1.24	-0.46
	Q3k: Cut down or removed a tree on my property	1-2	1.55	0.50	-.0.20	-1.96
	Q3l: Donated time or money to a gardening, tree or landscape group	1-2	1.08	0.27	3.20	8.25

*This item was removed during principal component analysis in Chapter 4 because it loaded very weakly in comparison to the other measurement items.

Table 5.1. Descriptive statistics of scale items (continued).

Construct	Scale Items	Range	Mean	Standard Deviation	Skewness	Kurtosis
Tree Knowledge	Q6a: Knowledge about planting a tree	1-3	2.09	0.62	-0.07	-0.44
	Q6b: Knowledge about caring for a tree	1-3	1.97	0.58	0.01	-0.02
	Q6c: Knowledge about trimming a tree	1-3	1.94	0.62	0.04	-0.42
	Q6d: Knowledge about protecting a tree from insects and pests	1-3	1.58	0.60	0.50	-0.65
	Q6e: Knowledge about cutting down a tree	1-3	1.84	0.71	0.23	-1.00
	Q6f: Knowledge about identifying native trees to this area	1-3	1.75	0.67	0.34	-0.81
	Q6g: Knowledge about identifying diseased trees	1-3	1.55	0.59	0.57	-0.60
	Q6h: Knowledge about selecting a suitable tree for your landscape	1-3	1.85	0.63	0.12	-0.54
	Q6i: Knowledge about buying a healthy tree	1-3	1.87	0.65	0.13	-0.66
Basis of Satisfaction with Tree Places	Q8a: Importance of tree shade	1-4	2.73	0.48	-1.40	0.84
	Q8b: Importance of trees marking seasonal change	1-4	2.49	0.63	-0.84	-0.31
	Q8c: Importance of trees for privacy	1-4	2.57	0.58	-1.00	0.01
	Q8d: Importance of trees decreasing energy costs	1-4	2.55	0.60	-1.02	0.04
	Q8e: Importance of trees slowing wind	1-4	2.29	0.69	-0.45	-0.86
	Q8f: Importance of trees improving air quality	1-4	2.74	0.49	-1.69	2.04
	Q8g: Importance of trees reducing street noise	1-4	2.51	0.63	-0.91	-0.20
	Q8h: Importance of trees providing wildlife habitat	1-4	2.68	0.54	-1.48	1.26
	Q8i: Importance of trees producing attractive blooms	1-4	2.45	0.64	-0.76	-0.47
	Q16: If relocating to new place to live, importance of having trees on property*	1-4	3.51	0.72	-1.66	2.88

*This item was removed during principal component analysis in Chapter 4 because it loaded very weakly in comparison to the other measurement items.

Table 5.1. Descriptive statistics of scale items (continued).

Construct	Scale Items	Range	Mean	Standard Deviation	Skewness	Kurtosis
Basis of Attachment to Tree Places	Q12a: Trees inspire community pride	1-5	4.31	0.81	-1.13	1.15
	Q12c: Trees in cities help people to feel calmer	1-5	4.14	0.86	-0.63	-0.31
	Q12h: Trees should not be planted in business districts because they block store signs (Q12h) **	1-5	4.13	1.03	-1.24	0.99
	Q12i: Trees enhance property	1-5	4.56	0.69	-2.00	5.65
	Q12k: Road widening projects should include more tree preservation and/or tree planting	1-5	4.13	0.95	-1.14	1.02
	Q12m: We need to have more trees in Knox County to cool and clean the air	1-5	4.30	0.83	-1.14	1.07
	Q15: Trees have a particular personal, symbolic, or spiritual meaning	1-3	2.16	0.93	-0.33	-1.76
Support for Local Tree Protection and Maintenance Policies	Q18a: More city/county funding is needed for planting trees in public areas (such as along streets, in schoolyards, and in parks	1-5	3.76	1.04	-0.69	0.13
	Q18b: It is important for utility districts to enforce proper trimming of street trees and protection of tree roots	1-5	4.37	0.73	-1.25	2.13
	Q18c: Our local government is spending enough money on saving or planting trees in Knox County**	1-5	3.03	0.83	0.07	1.24
	Q18d: Residential developers should cut down fewer trees when building new subdivisions in Knox County	1-5	4.37	0.86	-1.61	2.81
	Q18e: Commercial developers should not be required to protect old trees or plant new trees in Knox County**	1-5	4.25	1.05	-1.47	1.45
	Q18f: There should be stronger rules about protecting large old trees on private residential property	1-5	3.58	1.28	-0.54	-0.71

** To be consistent with the analysis of the other scale items, this question was reverse coded for analysis.

Kline (2011) recommends that corrective action be taken when working with variables with absolute values of skew greater than 3.0 and absolute values of kurtosis greater than 10.0, which suggests a problem with normality of the data. Multivariate normality is assumed for most CFA estimation methods, including maximum likelihood which is used in this study. Univariate normality measures shown for the study variables in Table 5.1 are an important indicator of multivariate normality (McDonald and Ho 2002). Two variables measuring the *Experience* construct were of concern because their skew and/or kurtosis values exceeded Kline's recommended cutoff values: Q3d (skew of 3.86 and kurtosis of 12.92) and Q3l (skew of 3.20 and kurtosis of 8.25). Therefore, these two variables were dropped from further analysis due to their potential contribution to multivariate non-normality. The new maximum skewness and kurtosis after Q3d and Q3l were dropped was 2.90 and 6.41, respectively (indicated by the variable Q3a, also of the construct *Experience*), which fell within Kline's rules of thumb for normality assessment.

Major findings are presented below. These are summaries of responses that Knox County homeowners gave on the survey, and are organized by construct.

Experience with Trees and Landscaping

A majority of respondents had significant exposure to tree care and other landscaping activities. Over half of the homeowners (56%) engaged in gardening, caring for trees, or lawn landscaping activities as a youth. Sixty-seven percent (67%) of the homeowners planted a tree in the past five years. Most homeowners (91%) had planted or maintained a home garden during the past year. Eighty-three percent (83%) have talked to others about gardening, tree care, or landscaping and 77% have read articles or watched programs about gardening, tree care, or landscaping. Few had consulted with a public agency about landscaping, donated time or money to a landscaping group, or attended classes or workshops about landscaping in the past year (12%, 8%, and 6%, respectively).

Tree Knowledge

Over half of the respondents were at least somewhat knowledgeable about planting, caring for, trimming, and cutting down trees; protecting trees from pests; identifying native trees; identifying healthy trees; and selecting suitable trees for a particular landscape. Homeowners knew the most about planting, caring for, and trimming trees (85%, 82%, and 77%, respectively); and knew the least about identifying a diseased tree, protecting a tree from pests, and identifying native trees (49%, 52%, and 61%, respectively).

Basis of Satisfaction with Tree Places

Homeowners identified air quality, wildlife habitat, and increased privacy as the most important contributions of trees (99%, 98%, 96%, and 95%, respectively). The least important characteristics of trees for area homeowners were their potential to slow wind, production of attractive blooms, and reduction of street noise (87%, 92%, and 93%, respectively).

Basis of Attachment to Tree Places

Knox County homeowners had a positive attitude toward places with urban trees. Respondents overwhelmingly agreed that trees increase property values (95%). A high percentage of survey respondents also felt that trees inspire community pride (85%) and that their town would benefit from having more trees to improve air quality and for their cooling effect (84%). Eighty percent (80%) were in favor of the inclusion of more street trees as part of road widening projects. There was a high level of *disagreement* with the statement “trees should not be planted in business districts because they block store signs” (80%). Three quarters of the homeowners felt that trees in cities help people to feel calmer. Just over half of respondents (59%) said that trees had a personal, symbolic, or spiritual meaning to them.

Public Support for Local Tree Protection and Maintenance Policies

Although Knox County homeowners were more supportive of practices to protect trees during construction of subdivisions and commercial developments, they expressed less willingness (or were uncommitted) to dedicating more public funding to improve tree management in these instances. They were also less supportive of having laws that may restrict their own ability to manage their private landscapes. Most homeowners felt that residential developers should cut down fewer trees when building subdivisions in Knox County (87%) and that developers of commercial property in Knox County should be required to protect old trees or plant new trees (81%). Also, just over half of the homeowners supported having stronger rules about protecting large old trees on private residential property (53%). Finally, a relatively small number of homeowners (20%) supported devoting more public funding to saving and planting trees in Knox County; however, a significant number (63%) were undecided or unsure about this issue.

Confirmatory Factor Analyses of the Model's Individual Constructs and Measurement Model (Step 1)

Amos™ was used to perform confirmatory factor analysis toward the development of the measurement model. A measurement model describes the nature of the relationship between (1) a number of latent variables, and (2) the manifest indicator variables that measure those latent variables. The model being investigated in the current study consists of five latent variables: Experience with Trees and Landscaping (*Experience*), Tree Knowledge (*Knowledge*), Basis of Satisfaction with Tree Places (*Basis of Satisfaction*), Basis of Attachment to Tree Places (*Basis of Attachment*), and Support for Local Tree Protection and Maintenance Policies (*Support*). In Step 2, urban tree *Canopy Density* manifest variables will be added to these five latent variables to create the final theoretical model depicted in Figure 3.1. For the purposes of explaining the analyses being performed in Step 1, I will also refer to the latent variables being tested as "constructs."

CFA was first used to test each construct individually before assembling the constructs into an overall measurement model to test each construct in the presence of the other constructs (Medsker, Williams, and Holahan 1994). This process provided evidence of construct validity that built on my initial assessment in Chapter 4 using Cronbach's alpha, since Cronbach's alpha is somewhat limited by the assumptions that (1) measurement items already form a unidimensional set and (2) the measurement items have equal reliabilities (Nunnally 1978, Anderson and Gerbing 1988). Construct validity – the extent to which each set of measured items actually reflected the theoretical latent construct they are designed to measure – was determined by assessing how well measurement items factored into theoretically predicted dimensions using CFA techniques, average variance extracted,[15] and Jöreskog's (1971) construct reliability.[16] These methods not only provide additional interpretation of the acceptability of the measurement scales associated with each construct (convergent validity) but also an indication of unidimensionality, an important aspect of discriminant validity.

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[15] AVE = $\Sigma\lambda_j^2 / [\Sigma\lambda_j^2 + \Sigma(1-\lambda_j^2)]$

[16] CR = $(\Sigma\lambda_j)^2 / [\Sigma(\lambda_j)^2 + \Sigma(1-\lambda_j^2)]$

Convergent validity was determined by measuring the extent to which indicators of a specific construct "converge" or share a high proportion of variance in common. CFA was used to examine factor loading patterns for measurement items representing each construct, looking for statistical significance and regression weights greater than 0.40 as recommended by Hatcher (1994), as well as goodness-of-fit statistics (Hayduk 1987, Jöreskog and Sörbom 1993). The average variance extracted (AVE) is an index that assesses the amount of variance that is captured by an underlying factor in relation to the amount of variance due to measurement error. The presence of convergent validity was supported if the AVE was greater than the threshold value of 0.50 (Fornell and Larcker 1981, Hatcher 1994). Finally, construct reliability (CR) was calculated, which is a measure of reliability and internal consistency based on the square of the total of factor loadings for a construct (Fornell and Larcker 1981). Convergent validity is supported if CR is greater than 0.70 (Hatcher 1994).

Other important Amos™ output used to assess and improve construct validity were the standardized regression weights (β), correlation residuals, standardized residuals, and modification indices (MIs) discussed in Chapter 4. Statistical significance of parameter estimates was also evaluated, based on a probability level of 0.05; insignificant parameters were eliminated. Based on these criteria, model modifications were made by eliminating the measurement items with low lambda weights or insignificant estimates. High correlation residuals, high standardized residuals, and high MIs were used to identify problematic parameters, as well. Finally, MIs were used to identify measurement items that should covary within a single dimension (provided that these modifications made theoretical sense), thus improving overall fit.

The first part of this section focuses on CFA of the model's individual constructs, followed by CFA of the measurement model.

Individual Constructs

CFA was conducted using Amos™ and maximum likelihood estimation for the five initial constructs individually: *Experience, Knowledge, Basis of Satisfaction, Basis of Attachment*, and *Support.* This calculation was used to check initial factor loadings and fit statistics. The term "maximum likelihood" describes the statistical principal that underlies the derivation of the parameter estimates; the estimates are the ones that "maximize the likelihood" that data were drawn from this population. AVE and CR values were also calculated. Fit statistics, AVE, and

CR of the measurement models of each construct are provided within each figure showing modeling results. In the sections that follow, observations are presented about the initial fit of each hypothesized construct and modifications that were made to improve each model.

Experience with Trees and Landscaping

Figure 5.1 (a) presents the initial hypothesized structure of the “Experience with Trees and Landscaping” (*Experience*) construct and the fit indices from the model estimation process. Although Amos™ output indicated that all of the loadings for the 11 observed items measuring *Experience* were significant, three variables had standardized loadings that were less than 0.4: Q1, *Frequency working in the yard when growing up* (0.32); Q3g, *Contacted a public agency or official about home gardening, tree care or general landscaping* (0.21); and Q3k, *Cut down or removed a tree on my property* (0.26). These three items were deleted. The rest of the observed variables had standardized loadings in the range of 0.44 – 0.70. This hypothesized construct had the lowest AVE of all the initial construct models (0.24), which may be due to the relatively low loadings of all the measurement items. The CR value of 0.76, however, was adequate since it exceeded the cutoff of 0.7, thus suggesting convergent validity despite the low AVE. An examination of correlation residuals did not indicate any absolute values greater than 0.10, as recommended by Kline (2011). There was evidence of model misspecification of error terms associated with Q2 (*Planted a tree in the past five years*) and Q3h (*Planted a tree on my property*) as indicated by a very high MI (errQ2↔errQ3h; MI=179.7). As explained in Chapter 4, MIs are provided by AMOS™ output, and are calculated for every path that is fixed to zero. The MI is a measure of how much $\chi 2$ would decrease if a particular fixed-to-zero parameter were to be freely estimated. Thus, the greater the value of an MI, the better the predicted improvement in overall fit if that path were added to the model (Kline 2011). Since the two items in question both measure different aspects of experience planting a tree, the model was modified to show covariance between Q2 and Q3h and re-estimated using Amos™.

Goodness of fit statistics for the respecified model showed that these modifications made a large improvement to model fit, which are shown alongside Figure 5.1 (b). The $\chi 2$ statistic decreased from 384.9 to 70.5, although it was still significant, thus rejecting H_0 that states that the model is an exact fit. However, all of the other model fit statistics made substantial improvements: $\chi 2/df$ decreased from 8.75 to 3.71, CFI increased from 0.784 to 0.963, RMSEA

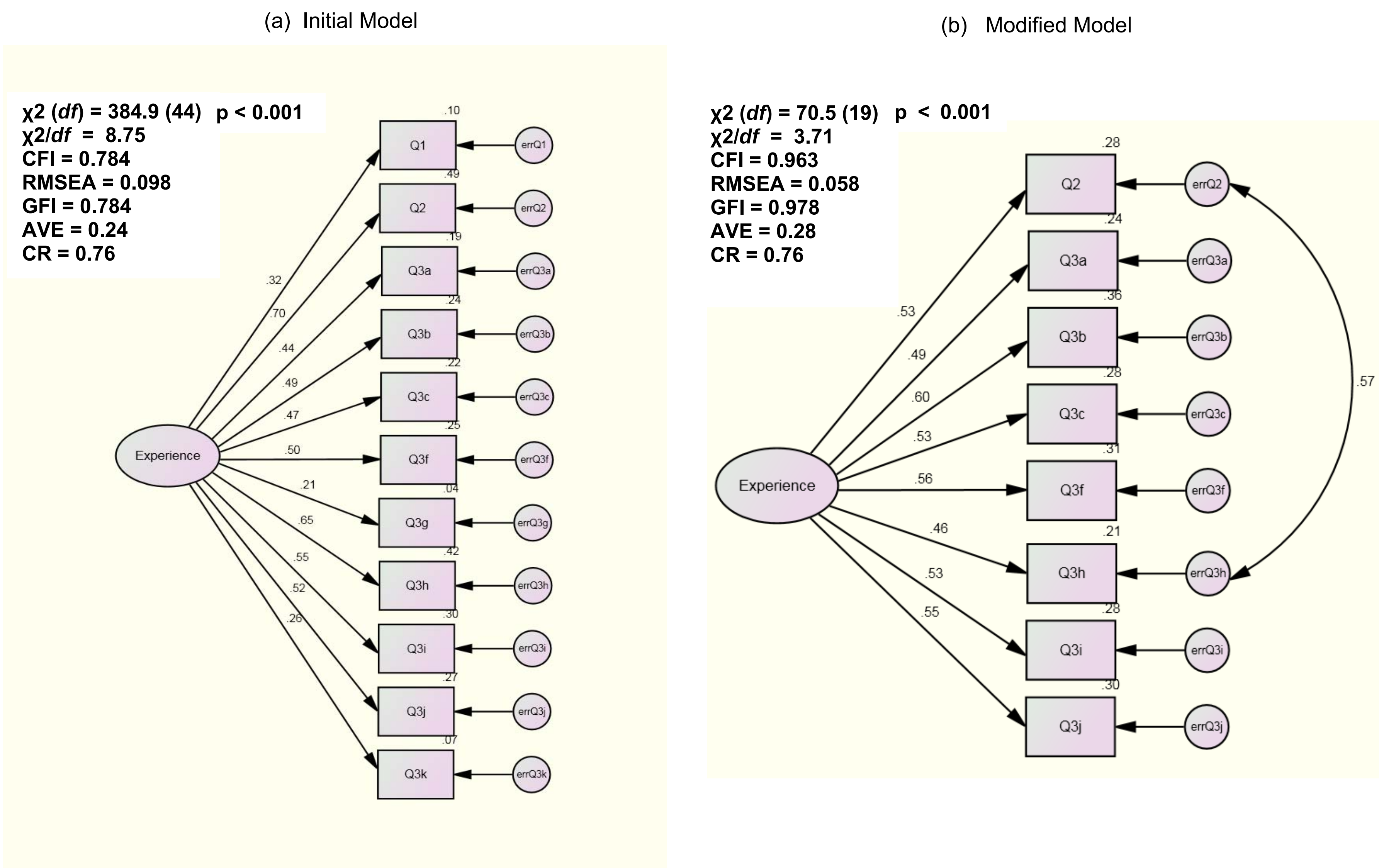

Figure 5.1. Results of CFA for *Experience*

decreased from 0.098 to 0.058, and GFI increased from 0.784 to 0.978.[17] Examination of MIs did not indicate any outliers. The AVE value of 0.28 was still significantly below the desired level of 0.50 or greater, which contradicts the validity of this construct as indicated by the other model fit statistics, but may be less of a concern because of the very conservative nature of this test (Hatcher 1994).

The fact that the $\chi 2$ statistic was significant suggested that the fit of the data to the hypothesized model was not a perfect fit. Although the significant $\chi 2$ could be attributed to correlated measurement error (a common problem in self-reported data in behavior sciences), fit could have also been compromised by the relatively large sample size in this study and deviation from normality for some variables, as shown in Table 5.1 (Kline 2011). In this situation, the SEM literature recommends to turn to the alternative measures of fit for a further check on validity (Bollen and Long 1993, McDonald and Marsh 1990). The CFI, RMSEA, and GFI measures all improved to indicate adequate model fit. Standardized regression weights, correlation residuals, and standardized residuals indicated all values fell within acceptable ranges. Therefore, SEM analysis proceeded using this respecified model of the construct *Experience* using the 8 items in Figure 5.1 (b).

Tree Knowledge

Figure 5.2 (a) presents the initial hypothesized structure of the “Tree Knowledge” (*Knowledge*) construct and the fit indices from the model estimation process. All 9 items measuring *Knowledge* were significant and of acceptable loadings (0.55-0.84). An examination of correlation residuals did not indicate any values greater than 0.10. The AVE and CR values were the highest of all the initial specifications for the model constructs, at 0.50 and 0.90, respectively, indicating convergent validity. There was evidence of model misspecification of

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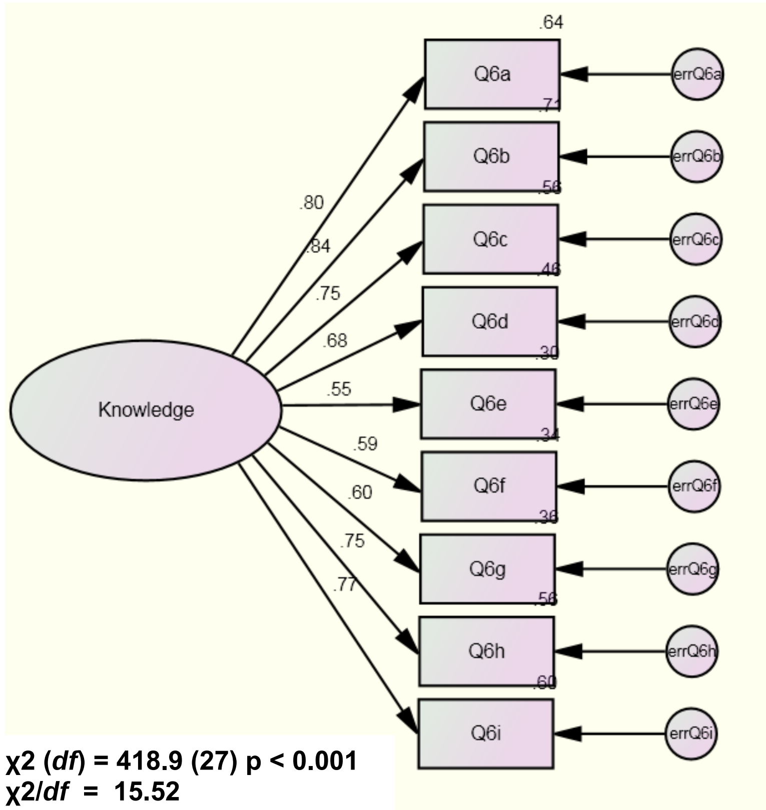
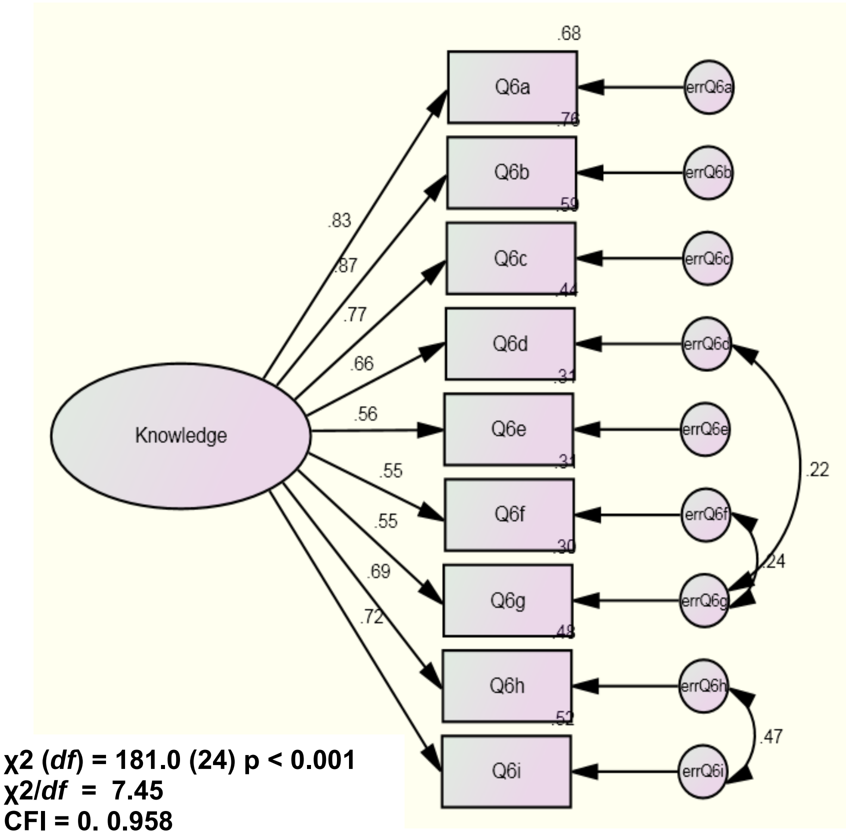
[17] As outlined in Chapter 4, it is recommended that the following guidelines be used to assess a good model fit: a $\chi 2/df$ ratio $<$ 5:1; CFI $>$ 0.95; RMSEA of 0.05 to 0.08; and GFI $>$ 0.90.

(a) Initial Model



$\chi 2$ (*df*) = 418.9 (27) p < 0.001
$\chi 2$/*df* = 15.52
CFI = 0.896
RMSEA = 0.135
GFI = 0.885
AVE = 0.50
CR = 0.90

(b) Modified Model



$\chi 2$ (*df*) = 181.0 (24) p < 0.001
$\chi 2$/*df* = 7.45
CFI = 0. 0.958
RMSEA = 0.090
GFI = 0.952
AVE = 0.49
CR = 0.89

Figure 5.2. Results of CFA for *Knowledge*.

error terms[18] associated with Q6h (*Knowledge about selecting a suitable tree for your landscape*) and Q6i (*Knowledge about buying a healthy tree*) as indicated by a very high MI (errQ6h↔errQ6i; MI=138.5). The suggested covariance made substantive sense, since “selection” and “buying” a tree are similar concepts. Therefore, the model was modified to show covariance between errQ6h and errQ6i and re-estimated using Amos™.

Goodness of fit statistics for the respecified model showed that these modifications made some improvement to model fit. The $\chi 2$ statistic decreased from 418.9 to 265.2, but was still significant, thus indicating that the model was not a perfect fit. Other model fit statistics made modest improvements: $\chi 2/df$ decreased from 15.5 to 10.2, CFI increased from 0.896 to 0.936, RMSEA decreased from 0.135 to 0.107, and GFI increased from 0.885 to 0.925. Examination of MIs for this new model suggested that model fit may be further improved by specifying covariance between errQ6a (*Knowledge about planting a tree*) and errQ6b (*Knowledge about caring for a tree*); errQ6g (*Knowledge about identifying diseased trees*) and errQ6f (*Knowledge about identifying native trees to this area*); errQ6g and errQ6b (*Knowledge about caring for a tree*); and errQ6g and errQ6d (*Knowledge about protecting a tree from insects and pests*). These four MIs (50.5, 43.3, 35.3, and 34.1, respectively) were not as large as the one associated with the errQ6h↔errQ6i covariance, previously (138.5). In reviewing these pairs of parameters, only two were of interest: errQ6g ↔ errQ6f and errQ6g ↔ errQ6d. This is because knowledge of “identifying” either diseased or native trees could be considered a similar skill (errQ6g ↔ errQ6f) and knowledge of tree disease and insects that may lead to disease (errQ6g ↔ errQ6d) would be in the same area of expertise. Therefore, these two covariances were added to the model and the model was re-estimated.

The fit statistics of the newly re-estimated model with the three sets of covariances (errQ6h↔errQ6i, errQ6g ↔ errQ6f, and errQ6g ↔ errQ6d) improved further, but $\chi 2$ (181.0) was

[18] In SEM, error terms are associated with each observed variable, representing measurement error. This error reflects on the adequacy of the observed variables in measuring the related underlying factor of Knowledge. Measurement error derives from two sources: random measurement error (in the psychometric sense) and error uniqueness, a term used to describe error variance arising from some characteristic that is considered to be specific (or unique) to a particular indicator variable. The one-way arrow from the error term indicates the impact of the measurement error (random and unique) on the observed variable. Such error often represents nonrandom (or systematic) measurement error, and may contribute to inexact fit of the model.

still significant. The fit indices are shown alongside Figure 5.2 (b). As with the *Experience* construct, this suggested that the fit of the data to the hypothesized model was not entirely adequate, but could be attributed to correlated measurement error, deviation from normality for the observed variables, and/or the large sample size. Also, $\chi2/df$ was a little outside the recommended range of 2 – 5 ($\chi2/df$ = 7.5*).* Therefore, I turned to the alternative measures of fit for a further check on validity. The CFI and GFI measures all improved to indicate adequate model fit (0.958 and 0.952, respectively), but the RMSEA indicator was slightly above the recommended cutoff of 0.08 (0.09). Also, standardized regression weights, correlation residuals, and standardized residuals indicated all values fell within acceptable ranges. AVE and CR decreased very slightly, but not to the extent where this would be cause for concern. Despite the fact that the fit statistics were not the best that they could be, they were deemed adequate. SEM analysis proceeded using this respecified model of the construct *Knowledge* with the 9 indicators shown in Figure 5.2 (b).

<u>Basis of Satisfaction with Tree Places</u>

Figure 5.3 (a) presents the initial hypothesized structure of the Basis of Satisfaction with Tree Places (*Basis of Satisfaction*) construct and the fit indices from the model estimation process. All 9 items measuring Basis of Satisfaction with Tree Places (*Basis of Satisfaction*) were significant. The rest of the observed variables had standardized loadings in the range of 0.49-70. This hypothesized construct had a low AVE (0.35), but simultaneously exhibited an adequate CR value of 0.84, thus suggesting convergent validity despite the low AVE. An examination of correlation residuals did not indicate any values greater than 0.10. Examination of MIs for this new model suggested that model fit may be improved by specifying covariance between errQ8d (*Importance of trees decreasing energy costs*) and errQ8e (*Importance of trees slowing wind*); errQ8b (*Importance of trees marking seasonal shade*) and errQ8i (*Importance of trees producing attractive blooms*); and errQ8c (*Importance of trees for privacy*) and errQ8f (*Importance of trees improving air quality*). These MIs ranged from 36.2 to 79.0. In reviewing these pairs of parameters, errQ8b↔errQ8i (MI = 49.8) made the most sense, since these items both rated the importance of an aesthetic quality. The covariance errQ8d↔errQ8e (MI = 79.0) was not as theoretically strong as errQ8b↔errQ8i, but was of interest because of the high MI and the fact that the quality of shielding a residence from wind is slightly related to the ability of trees to reduce energy costs. Therefore, these two covariances were added to the model and the model re-estimated.

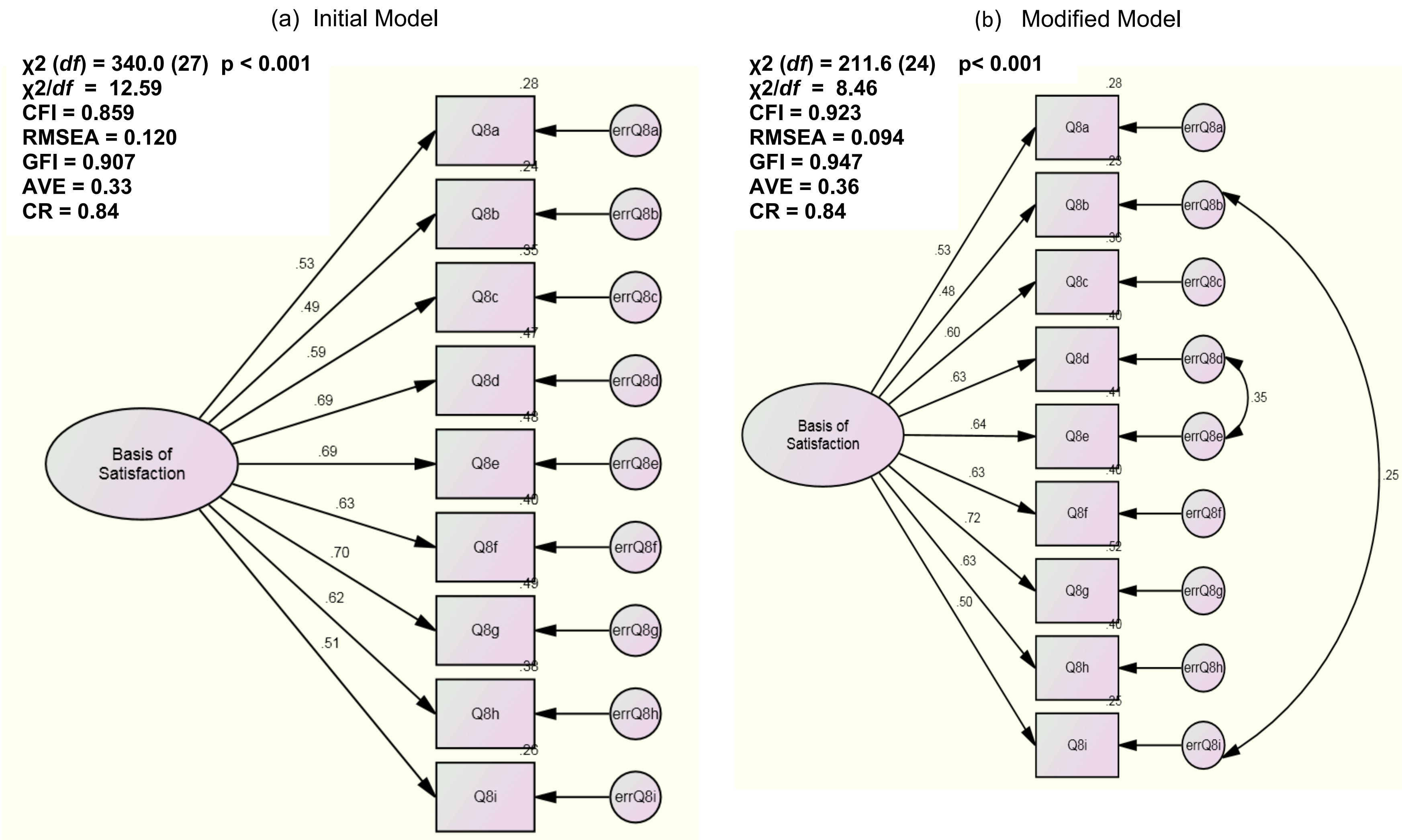


Figure 5.3. Results of CFA for *Basis of Satisfaction.*

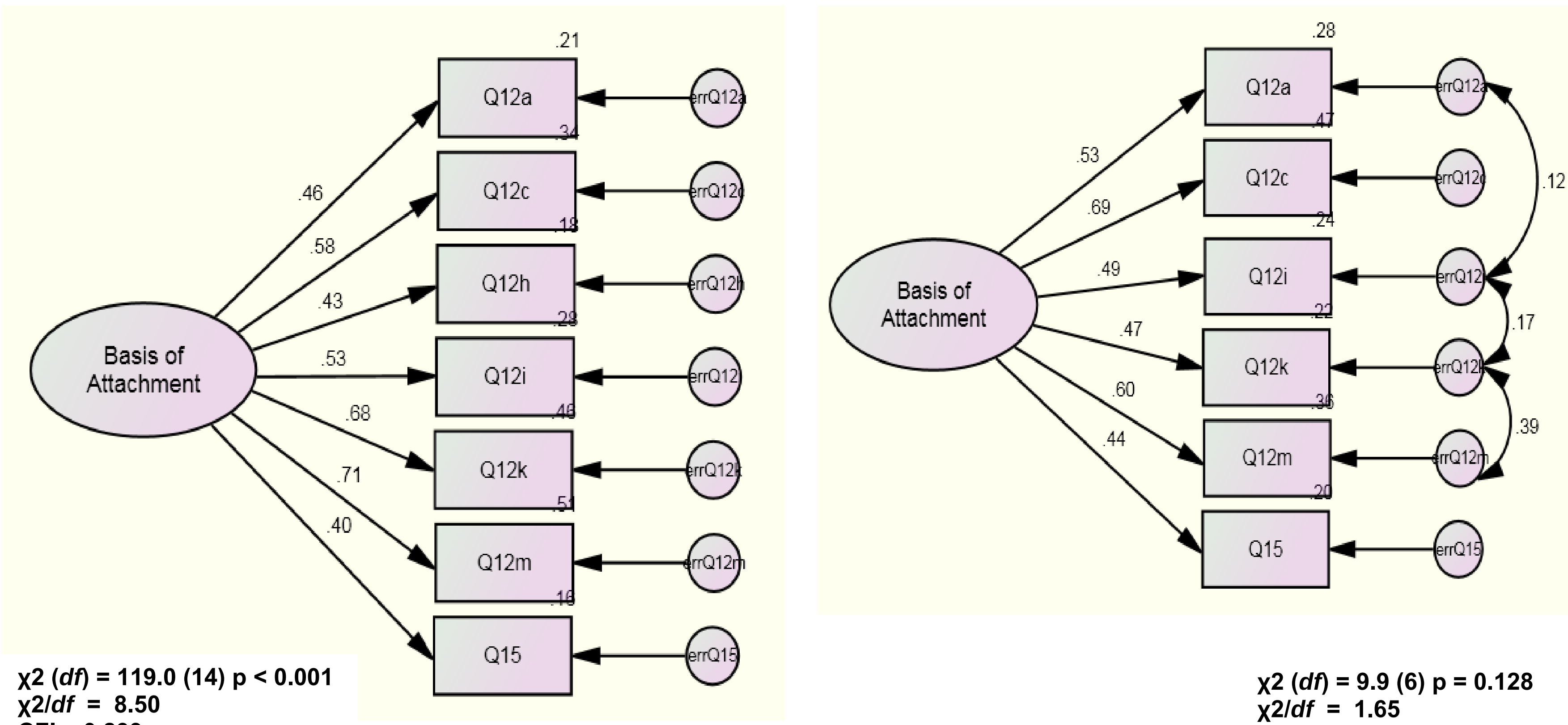
Goodness of fit statistics for the respecified model showed that these modifications made some improvement to model fit, which are shown alongside Figure 5.3 (b). The $\chi 2$ and $\chi 2/df$ measurements continued to be large for the *Basis of Satisfaction* construct (211.6 and 8.46, respectively), and $\chi 2$ was still significant, thus indicating that the model was not a perfect fit. However, this could be attributed to correlated measurement error, deviation from normality for the observed variables, and/or the large sample size. The $\chi 2/df$ measurement was also a little troubling since it was above the recommended cutoff of 5, but the modest improvements among other fit statistics alleviated some of the concern: CFI increased from 0. 855 to 0.916, RMSEA decreased from 0.109 to 0.097, and GFI increased from 0.908 to 0.944. Although RMSEA was a little high (greater than the recommended upper cutoff of 0.08), CFI and GFI indicated adequate model fit. Also, standardized regression weights, correlation residuals, and SRs indicated all values fell within acceptable ranges. AVE increased very slightly and CR remained unchanged in the final configuration of the model. SEM analysis proceeded using this respecified model of the construct *Basis of Satisfaction* with the 9 indicators shown in Figure 5.3 (b).

Basis of Attachment to Tree Places

Figure 5.4 (a) presents the initial hypothesized structure of the Basis of Attachment to Tree Places (*Basis of Attachment*) construct and the fit indices from the model estimation process. All 7 items measuring *Basis of Attachment* were significant and of acceptable loadings (0.40-71). This hypothesized construct had a low AVE (0.31), but simultaneously exhibited an adequate CR value of 0.75, thus suggesting convergent validity despite the low AVE. An examination of correlation residuals did not indicate any values greater than 0.10. Examination of MIs for this model suggested that model fit may be improved by specifying covariance between errQ12k (*Road widening projects should include more tree preservation and/or tree planting*) and errQ12m (*We need to have more trees in Knox County to cool and clean the air*); errQ12a (*Trees inspire community pride*) and errQ12i (*Trees enhance property values*); errQ12a and errQ12c (*Trees in cities help people to feel calmer*); and errQ12c and errQ12k. These MIs ranged from 16.7 to 23.6. The pair errQ12k↔ errQ12m (MI = 23.6) was retained since roadside trees are associated with cleaner air to most people (Schroeder, Flannigan, and Coles 2006). The pair errQ12a↔errQ12i (MI = 17.9) also seemed logical, since “community pride” is often linked to property values in U.S. society (Dwyer et al. 2000; Ellis, Lee, and Kweon 2006), it was also retained. The pair errQ12a↔errQ12c (MI = 16.7) was less evident in a possible association

(a) Initial Model

(b) Modified Model



χ2 (*df*) = 119.0 (14) p < 0.001
χ2/*df* = 8.50
CFI = 0.899
RMSEA = 0.097
GFI = 0.957
AVE = 0.31
CR = 0.75

χ2 (*df*) = 9.9 (6) p = 0.128
χ2/*df* = 1.65
CFI = 0.899
RMSEA = 0.029
GFI = 0. 996
AVE = 0.29
CR = 0.71

Figure 5.4. Results of CFA for *Basis of Attachment.*

(the feelings of “pride” and “calm”), and was not used in the respecified model. The last pair of interest, errQ12c↔errQ12k (MI = 22.4), seemed reasonable and is backed up in the literature (Zhang et al. 2007). However, it was not used because AMOS™ indicated a negative covariance between these two variables, which is the opposite of what would be expected. The model was then re-estimated after adding the two suggested covariances above.

Goodness of fit statistics for the respecified model showed that these modifications made a large improvement to model fit. The $\chi 2$ statistic decreased from 119.0 to 65.7, although it was still significant, thus indicating that the model was not a perfect fit. However, all of the other model fit statistics made substantial improvements: $\chi 2/df$ decreased from 8.50 to 5.47, CFI increased from 0.899 to 0.949, RMSEA decreased from 0.117 to 0.075, and GFI increased from 0.957to 0.975. Examination of MIs suggested that model fit may be improved by adding a covariance between errQ12h (*Trees should be planted in business districts*)[19] and errQ12k (*Road widening projects should include more tree preservation and/or tree planting*) (MI =17.7). This relationship seemed logical, since most downtown areas include mostly street trees, so this covariance was added and the model re-estimated again.

The lambda for Q12h in the respecified model (*Trees should be planted in business districts*) dropped to 0.39, so this variable was deleted. Fit statistics continued to improve, but $\chi 2$ (45.9) was still significant, thus indicating that the model was not a perfect fit. However, $\chi 2/df$, CFI, RMSEA, and GFI all improved further to indicate adequate model fit. Also, correlation residuals and standardized residuals indicated all values fell within acceptable ranges. AVE decreased slightly to 0.28 and CR decreased very slightly to 0.72. Examination of MIs suggested that model fit may be improved by adding a covariance between errQ12k (*Road widening projects should include more tree preservation and/or tree planting*) and errQ12i (*Trees enhance property values*) (MI = 14.9). This relationship seemed plausible, since street trees have been found to increase property values (Wolf 2007). Therefore, this covariance was added and the model re-estimated without Q12h and with the new errQ12k↔errQ12i covariance.

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[19] It should be noted that in the original questionnaire, Q12h was actually asked in a negative sense, then reverse coded for analysis.

Examination of the fit statistics for the respecified model show continued improvement, and are shown alongside Figure 5.4 (b). The $\chi 2$ statistic (9.9) was no longer significant, indicating that H_0 was accepted (the model is valid). AVE increased slightly to 0.29 and CR increased to 0.71 in this final configuration of the model. SEM analysis proceeded using this respecified model of the construct *Basis of Attachment* with the 6 indicators shown in Figure 5.4 (b).

Public Support/Opposition for Local Tree Protection and Maintenance Policies

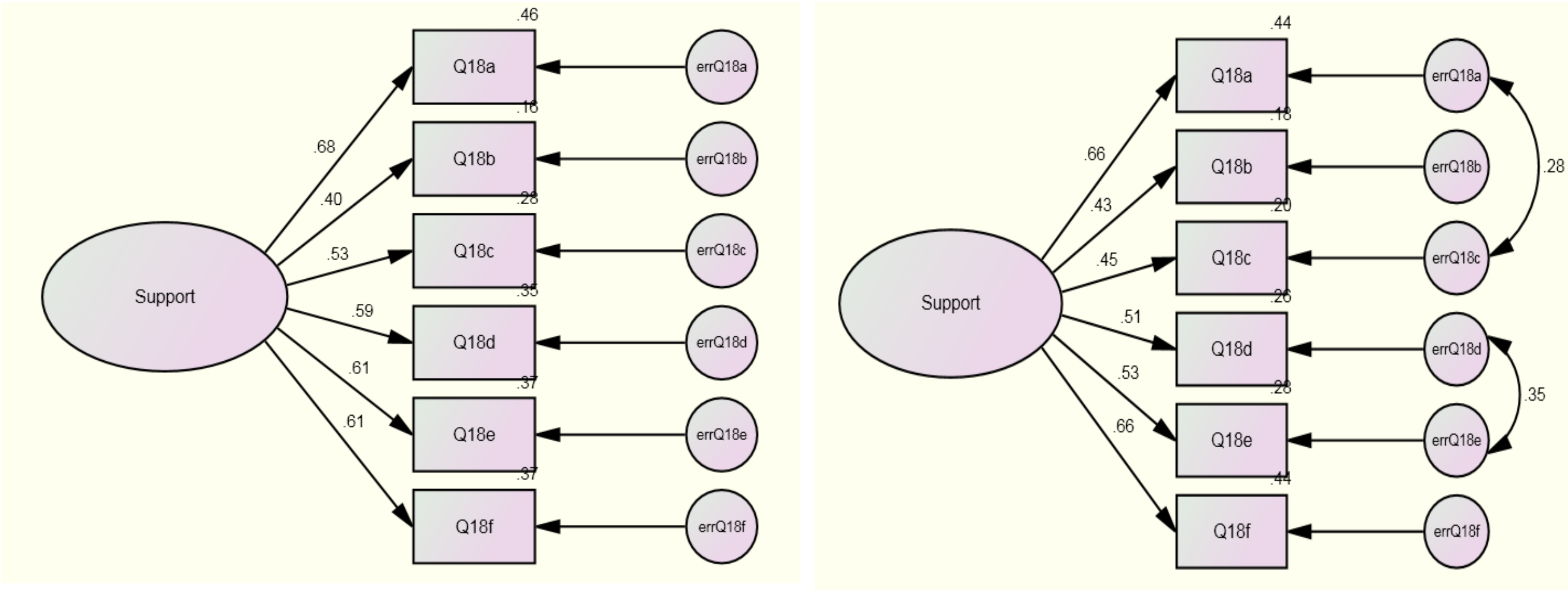
Figure 5.5 (a) presents the initial hypothesized structure of the Public Support/Opposition for Local Tree Protection and Maintenance Policies (*Support*) construct and the fit indices from the model estimation process. All 6 items measuring *Support* were significant and of acceptable loadings (0.40-0.68). This hypothesized construct had a low AVE (0.33), but also exhibited an adequate CR value of 0.74, thus suggesting convergent validity despite the low AVE. An examination of correlation residuals indicated one pair of indicators exhibiting an absolute value > 0.10. This value, 0.113, reflected the association between Q18a (*More city/county funding is needed for planting trees in public areas*) and Q18c (*Our local government needs to spend more money on saving or planting trees in Knox County*).[20] However, an examination of MIs for this initial *Support* model suggested that model fit may be improved by specifying covariance between the residual error terms for these two observed variables (MI = 36.7). This was done in the respecified model, since these two questions were very similar. Another elevated MI was noted that suggested the need for a covariance between errQ18d (*Residential developers should cut down fewer trees when building new subdivisions in Knox County*) and errQ18e (*Commercial developers should be required to protect old trees or plant new trees in Knox County*)[21] (MI = 58.4). This association seemed logical since both questions addressed development in Knox County. After adding these two covariances, the model was re-estimated.

Goodness of fit statistics for the respecified model showed that these modifications made substantial improvement to model fit. The $\chi 2$ statistic decreased from 107.8 to 7.1, and was no

[20] It should be noted that in the original questionnaire, Q18c was actually asked in a negative sense, then reverse coded for analysis.

[21] It should be noted that in the original questionnaire, Q18e was actually asked in a negative sense, then reverse coded for analysis.

(a) Initial Model (b) Modified Model



χ2 (*df*) = 107.8 (9) p < 0.001
χ2/*df* = 11.98
CFI = 0.875
RMSEA = 0.128
GFI = 0.946
AVE = 0.33
CR = 0.74

χ2 (*df*) = 7.1 (7) p = 0.415
χ2/*df* = 1.02
CFI = 1.000
RMSEA = 0.005
GFI = 0. 996
AVE = 0.30
CR = 0.71

Figure 5.5. Hypothesized CFA model of *Support.*

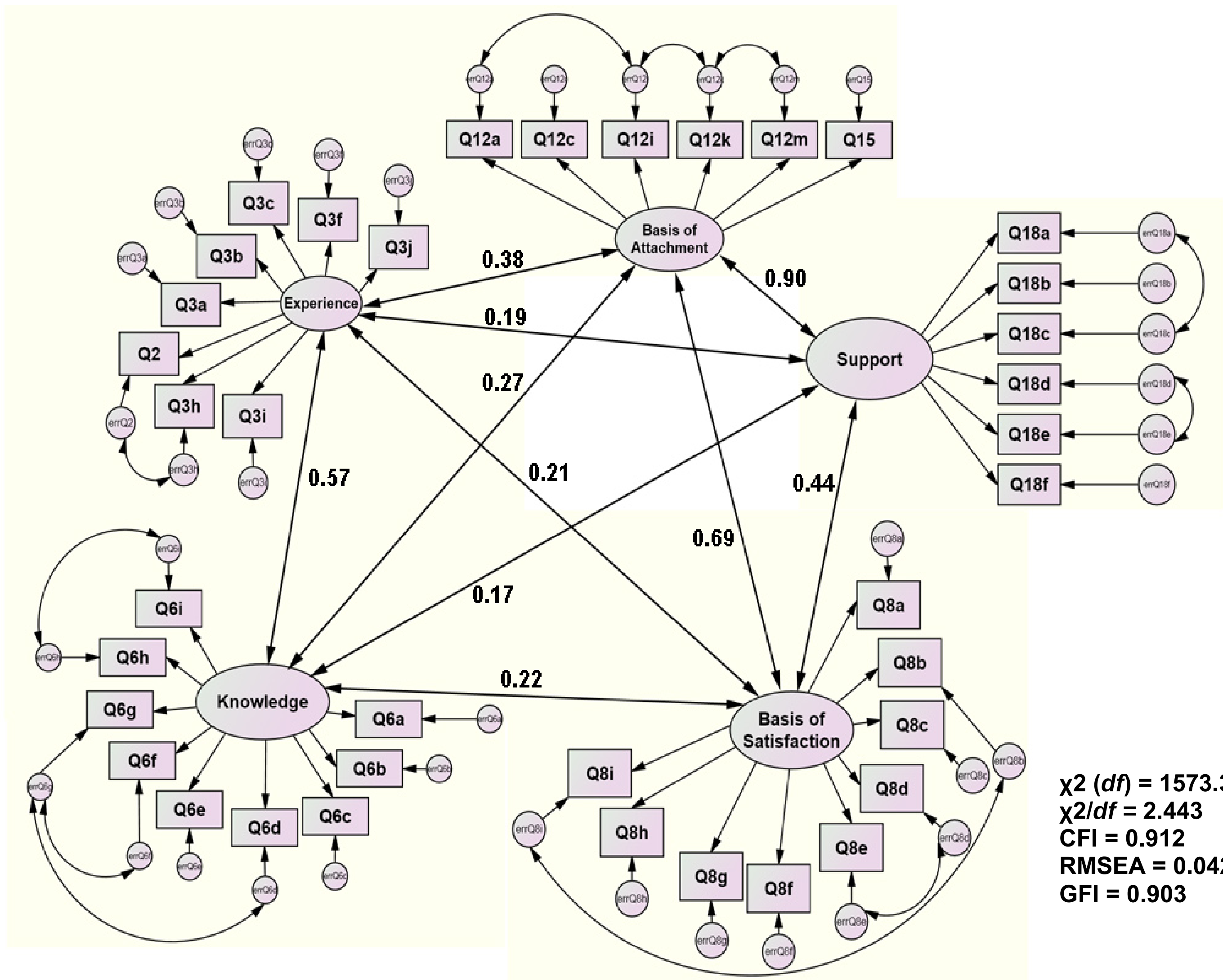
longer significant, thus accepting H_0 that states that the model is valid. All of the other model fit statistics made substantial improvements: $\chi 2/df$ decreased from 11.98 to 1.02, CFI increased from 0.875 to 1.000, RMSEA decreased from 0.128 to 0.005, and GFI increased from 0.946 to 0.996. Standardized regression weights, correlation residuals, and standardized residuals indicated all values fell within acceptable ranges. Also, AVE decreased very slightly to 0.30 and CR decreased very slightly to 0.71 in this final configuration of the model. SEM analysis proceeded using this respecified model of the construct *Support* with the 6 indicators shown in Figure 5.5 (b).

Measurement Model

Further "purification" of the scales used to define the latent constructs in this study was conducted by combining all five constructs into one "measurement model." CFA was conducted for the measurement model, in which the refined models for each individual construct were correlated with each other. To review, the model investigated in this study consisted of five latent variables corresponding to the five constructs of the hypothesized model: Life Experience with Trees and Landscaping (*Experience*), Tree Knowledge (*Knowledge*), Basis of Satisfaction with Tree Places (*Basis of Satisfaction*), Basis of Attachment to Tree Places (*Basis of Attachment*), and Public Support/Opposition for Local Tree Protection and Maintenance Policies (*Support*). Each of the five latent variables was measured by at least six manifest indicator variables (total of 38 observed variables for the five constructs). The measurement model posits no unidirectional paths between latent variables, as in the structural model which will be presented later in this chapter. Instead, in the measurement model, a covariance is estimated to connect each latent variable with every other latent variable.

Amos™ was successful in converging on a solution to estimate model parameters for the measurement model. The covariance matrix of the measurement model was positive definite, indicating that multicollinearity was not a concern in evaluating the model. A graphical depiction of the measurement model is shown in Figure 5.6 with the correlations between pairs of constructs.

With the exception of a significant $\chi 2$ statistic, the fit indices indicated that the total measurement model adequately fit the data. The fact that the $\chi 2$ statistic was significant suggested that the model was not a perfect fit. However, this could be attributed to correlated measurement error, deviation from normality for the observed variables, and/or the large sample



$\chi2$ (*df*) = 1573.3 (644), p < 0.001
$\chi2$/*df* = 2.443
CFI = 0.912
RMSEA = 0.042
GFI = 0.903

Figure 5.6. Measurement model (all regression weights significant; p < 0.001)

size, thus rejecting H_0 that states that the model is valid (1573.3; $p < .001$). However, all of the other model fit statistics generally indicated otherwise. The $\chi 2$/df ratio was within the suggested range of 2 to 5 (2.44) indicating a good fit, while the CFI, RMSEA, and GFI values were within acceptable ranges (0.912, 0.042, and 0.903, respectively).

More importantly, absolute values of all 703 correlation residuals were all under 0.10, except for three. Hu and Bentler (1995) note:

> If the discrepancy between the observed correlations and model-reproduced correlations are very small, clearly the model is good at accounting for the correlations, no matter what the $\chi 2$ test or fit indexes seem to imply. (p. 98)

The residual absolute values of the three pairs of variables that had the largest discrepancies were 0.126, 0.131 and 0.139, and represented the correlations between the observed variables Q6e (*Knowledge about cutting down a tree*) and Q18a (*More city/county funding is needed for planting trees in public areas*); Q12k (*Road widening projects should include more tree preservation and/or tree planting*) and Q18e (*Commercial developers should be required to protect old trees or plant new trees in Knox County*);[22] and Q6e and Q18f (*There should be stronger rules about protecting large old trees on private residential property*), respectively. In this case, Hu and Bentler (1995) suggest that if values exceeding the recommended cutoff of 0.10 are present, then the model is only “marginally wrong for some variables” (p. 98). When analyzing the MI previously for the *Knowledge* construct, Variable Q6e showed up in four suggested covariances. To review, a MI is a univariate modification index expressed as the drop in the $\chi 2$ statistic when a particular fixed-to-zero path is freely estimated; this serves to estimate the improvement of fit a model may have as a result of this modification. Amos™ also generates an expected parameter change (EPC) associated with the MI (Jöreskog and Sörbom 1993, Byrne 2010). Since the highest MI was only 13.7 (resulting in an EPC of -0.026), and indicated covariances among variables that did not make theoretical sense, the model for the *Knowledge* construct was not modified to add these covariances with Q6e. An analysis of bivariate correlations between Q6e and Q18a (-0.107, $p < 0.01$), Q6a and Q18f (0.098, $p < 0.05$), and

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[22] It should be noted that in the original questionnaire, Q18e was actually asked in a negative sense, then reverse coded for analysis.

Q6e and Q18f (0.039, $p > 0.05$) did not appear unusual. Since these three residuals were the only statistically significant discrepancy of note among 703 correlations in the measurement model, no modification was made to the measurement model.

This second part of “Step 1” also serves to test discriminant validity, which refers to the extent in which a certain construct is different from other constructs (Chen, Aryee, and Lee 2004). It means that items from one scale should not load or converge too closely with items from a different scale and that different latent variables which correlate too highly may indeed be measuring the same construct rather than different constructs (Garver and Mentzer 1999). Therefore, relatively low correlations or no correlation between variables indicates the presence of discriminant validity (Campbell and Fiske 1959, Bollen 1989).

Discriminant validity was tested by running a series of nested CFA model comparisons in which the covariance between each pair of constructs (one pair at a time) was constrained to 1 (Anderson and Gerbing 1988; Bagozzi and Yi 1988). When the covariance is constrained, the model contains one additional degree of freedom. With 1 *df*, the critical value of $\chi2$ at $p=0.05$ is 3.841. So if the difference in $\chi2$ values ($\chi2_d$) between the standard measurement model and the new measurement model (with the covariance restrained) is greater than 3.841, the difference is significant. In other words, the standard measurement model in which the factors are viewed as distinct but correlated constructs provided a fit that was significantly better than the fit provided by the “unidimensional” model (the model with the constrained correlation between one pair of factors). The $\chi2_d$ tests for nine of the ten pairs of constructs were significant at $p < 0.05$, generally indicating that the distinct theoretical constructs posed a better fit. When the covariance was restrained between *Experience* and *Basis of Satisfaction*, $\chi2_d$ was not significant, indicating that there may be some concern about the discriminant validity between these two constructs. It was not immediately clear why this would have occurred, since the observed variables associated with these constructs did not have excessive bivariate correlations, nor were the survey questions in any way similar. The correlation between the two latent constructs was relatively low at 0.206, which further contradicts this finding. Therefore, SEM analyses were continued with *Experience* and *Basis of Satisfaction* left as separate constructs. Table 5.2 summarizes the $\chi2_d$ tests for the ten pairs of constructs.

Finally, intercorrelations between the constructs were evaluated, as shown on Figure 5.6. Ideally, intercorrelations should be less than 0.70, which suggests the constructs had less than

Table 5.2. Results of chi-square difference test ($\chi2_d$) to assess discriminant validity.

Construct	Experience	Knowledge	Basis of Satisfaction	Basis of Attachment	Support
Experience					
Knowledge	**105.4**				
Basis of Satisfaction	**0.4***	**109.6**			
Basis of Attachment	**16.4**	**9.8**	**21.4**		
Support	**113.2**	**21.5**	**123.5**	**45.1**	

*All $\chi2_d$ are significant for $p < 0.05$ except for the $\chi2_d$ between Basis of Satisfaction and Experience.

half their variance in common (MacKenzie, Podsakoff, and Jarvis 2005). All pairs of constructs met this cut-off except for the correlation between *Basis of Attachment* and *Support*. It is not surprising that these two constructs were highly correlated (0.903), since positive feelings toward trees measured by *Basis of Attachment* would logically feed into support for maintaining the local urban forest, as measured by *Support*.

Structural Model Evaluation (Step 2)

In the previous section, confirmatory factor analysis was used to develop an acceptable measurement model, as well as to assess convergent and discriminant validity of the hypothesized constructs. This represented the first step of the two-step procedure recommended by Anderson and Gerbing (1988), in that there were no directed arcs (paths) to indicate direct effects of one construct on another. Only nondirected arcs were used, which represented correlated disturbances, which are random terms corresponding to variations not explained by the model.

This section presents the results of the analysis of the second step of the two-step procedure, where the measurement model was modified to specify causal relationships between the latent variables, as represented by the hypotheses presented in Chapter 4. This theoretical “causal” model,[23] or structural regression (SR) model is actually a combined structural model of the measurement model and a “path model” that describes relations of dependency between the latent variables. The SR model serves to structure the covariance matrix of the common factors.

In building up to the hypothesized SR model presented in Figure 3.1, the relationships hypothesized in Chapter 3 were tested first on the five latent variables only in the baseline model, followed by addition the *Canopy Density* variable using varying radii to represent different size buffer zones. The first part of this section presents the results of the goodness of fit analysis of hypothesized relationships among the latent variables only. This is followed by analysis results of the same model using the same procedure while controlling for tree canopy density. In addition to testing study hypotheses in the final version of the model, this stepwise procedure was performed in order to gain an understanding of the relative contributions of the biophysical manifest variables to the baseline model.

Baseline Analysis: Structural Regression Model for the Five Latent Variables Only

In this first iteration of Step 2, the hypothetical structural regression model with the five constructs *Experience, Knowledge, Basis of Satisfaction, Basis of Attachment,* and *Support* was evaluated. This is the theoretical model shown in Figure 3.1 without controlling for the effect of *Canopy Density*. This baseline analysis does not address the hypotheses outlined in Chapter 2; these will be discussed later in this chapter when the biophysical manifest variables have been added to this baseline model. Figure 5.7 shows the configuration of this baseline model and the results (note that for ease of interpretation, the latent variables are shown without the indicator variables).

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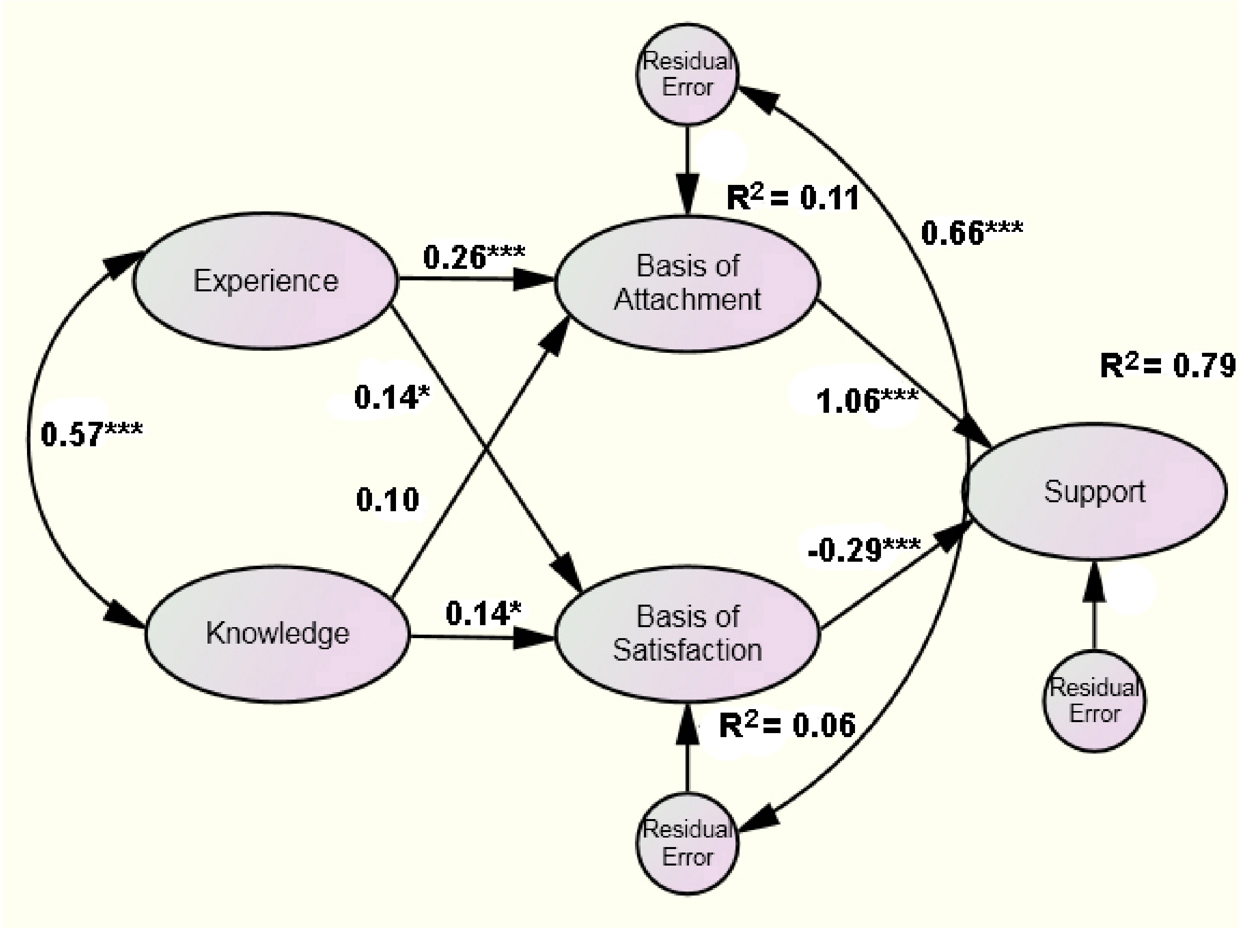
[23] In the interest of avoiding a misleading oversimplification of the use of the concept of “causality,” causal ordering of constructs as hypothesized by this study should be interpreted as a causally distributed pattern of individual expressions and resulting practices and behavior in a limited cultural context. Further, the “causal model” more accurately represents possible relationships among individuals’ perceptions, experiences, and actions as represented by the constructs, indicating plausible inferences in this study’s limited framework of relevancy to environmental values and behavior. As such, the model is intended to portray the conditions and relations that may have broader implications for potential public dialogue about the relationships among environmental attitudes, environmental policies under consideration, and the possible outcomes of these policy interventions.



χ2 (*df*) = 1607.2 (647), p < 0.001

χ2/*df* = 2.484

CFI = 0.909

RMSEA = 0.043

GFI = 0.901

* p < 0.05
** p < 0.01
*** p < 0.001

Figure 5.7. Baseline analysis of theoretical model without tree canopy density variable.

The recursive model was estimated using the maximum likelihood method, and was identified. The chi-square value ($\chi 2 = 1561.4$, $df = 644$), was statistically significant ($p < 0.001$), thus rejecting H_0 that states that the model is an exact fit. Technically, when the proper assumptions are met, this chi-square statistic may be used to test H_0 that states the model fits the data. In practice, however, this statistic is very sensitive to correlations of observed variables, variables with high proportions of unique variance, sample size, and any non-normality of observed variables, thus often resulting in the rejection of a well-fitting model (Byrne 2010). Other fit indices of the structural model were: $\chi 2/df = 2.424$, CFI = 0.913, RMSEA = 0.042, and GFI = 0.904, which were generally indicative of an acceptable fit. Standardized regression estimates and their significance were also estimated (shown on Figure 5.7); only one path was insignificant (based on the probability level of 0.05; $p > 0.05$): *Knowledge → Basis of Attachment*. This path was subsequently dropped from the model. Table 5.3 presents the maximum likelihood estimates for the model parameters.

Two of the other results for the standardized regression weights indicated there was in fact a significant problem with the model's fit. In a review of the estimates of standardized regression weights, there was one value that was of concern given that its value exceeded 1.00; this represented the path flowing from *Basis of Attachment* to *Support*. This aberrant estimate signaled the need for further investigation (Byrne 2010). Also, the path coefficient between *Basis of Satisfaction* and *Support* was negative ($\beta = -0.29$), which was not the sign expected. This would imply that an individual who finds various attributes of trees to be important (i.e., improving air quality; reducing noise, wind, and energy costs; providing shade, wildlife habitats and privacy) would not be likely to support urban tree canopy protection measures. One possible explanation for the problematic path coefficient between *Basis of Attachment* and *Support* is that there is an overlap of content in the items measuring these two constructs. Indeed, if these two sets of measures are combined into one construct, all of the standardized loadings are greater than 0.40, despite the $\chi 2$ difference test conducted for these two constructs having indicated discriminant validity (see Table 5.2). However, the indicators for *Support* and *Basis of Attachment* are also theoretically distinct, in that the former focus on agreement with regulatory measures to protect tree canopy and the latter are more generally oriented toward attachment to tree places. Therefore, these two constructs were kept separate. Next, I turned to the possibility that a suppression effect was occurring due to the fact that the direct and

Table 5.3. Parameter estimates for the study models.

Model	Parameter	Unstandardized Estimate [1]	Standard Error	Critical Ratio [2]	Standardized Estimate	p [3]
Baseline (Initial)	Basis of Satisfaction <--- Experience	0.127	0.056	2.274	0.135	*
	Basis of Satisfaction <--- Knowledge	0.070	0.027	2.604	0.141	**
	Basis of Attachment <--- Experience	0.414	0.101	4.104	0.261	***
	Basis of Attachment <--- Knowledge	0.083	0.045	1.850	0.100	
	Support <--- Basis of Attachment	1.756	0.185	9.479	1.064	***
	Support <--- Basis of Satisfaction	-0.801	0.213	-3.765	-0.289	***
	Basis of Attachment <--> Basis of Satisfaction	0.065	0.008	8.427	0.662	***
	Knowledge <--> Experience	0.079	0.008	9.386	0.573	***
Baseline (Final)	Basis of Satisfaction <--- Experience	0.119	0.056	2.120	0.125	*
	Basis of Satisfaction <--- Knowledge	0.071	0.027	2.668	0.144	**
	Basis of Attachment <--- Experience	0.344	0.072	4.785	0.213	***
	Basis of Attachment <--- Basis of Satisfaction	1.017	0.112	9.082	0.573	***
	Support <--- Basis of Attachment	1.325	0.121	10.947	0.825	***
	Knowledge <--> Experience	0.079	0.008	9.402	0.580	***
Baseline + Tree Canopy Density (100' Radius) (Initial)	Basis of Satisfaction <--- Experience	0.112	0.056	2.004	0.119	*
	Basis of Satisfaction <--- Knowledge	0.070	0.027	2.596	0.141	**
	Basis of Attachment <--- Experience	0.342	0.072	4.764	0.214	***
	Basis of Attachment <--- Density	0.095	0.087	1.093	0.038	
	Basis of Satisfaction <--- Density	0.164	0.058	2.846	0.119	**
	Basis of Attachment <--- Basis of Satisfaction	0.995	0.111	8.941	0.589	***
	Support <--- Basis of Attachment	1.330	0.123	10.800	0.823	***
	Knowledge <--> Experience	0.079	0.008	9.379	0.575	***

1. Estimates for parameters with single-headed arrows are factor loadings and estimates for parameters with double-headed arrows factor covariances.
2. The critical ratio is the parameter estimate divided by its standard error.
3. * $p < 0.05$
   ** $p < 0.01$
   *** $p < 0.001$

Table 5.3. Parameter estimates for the study models (continued).

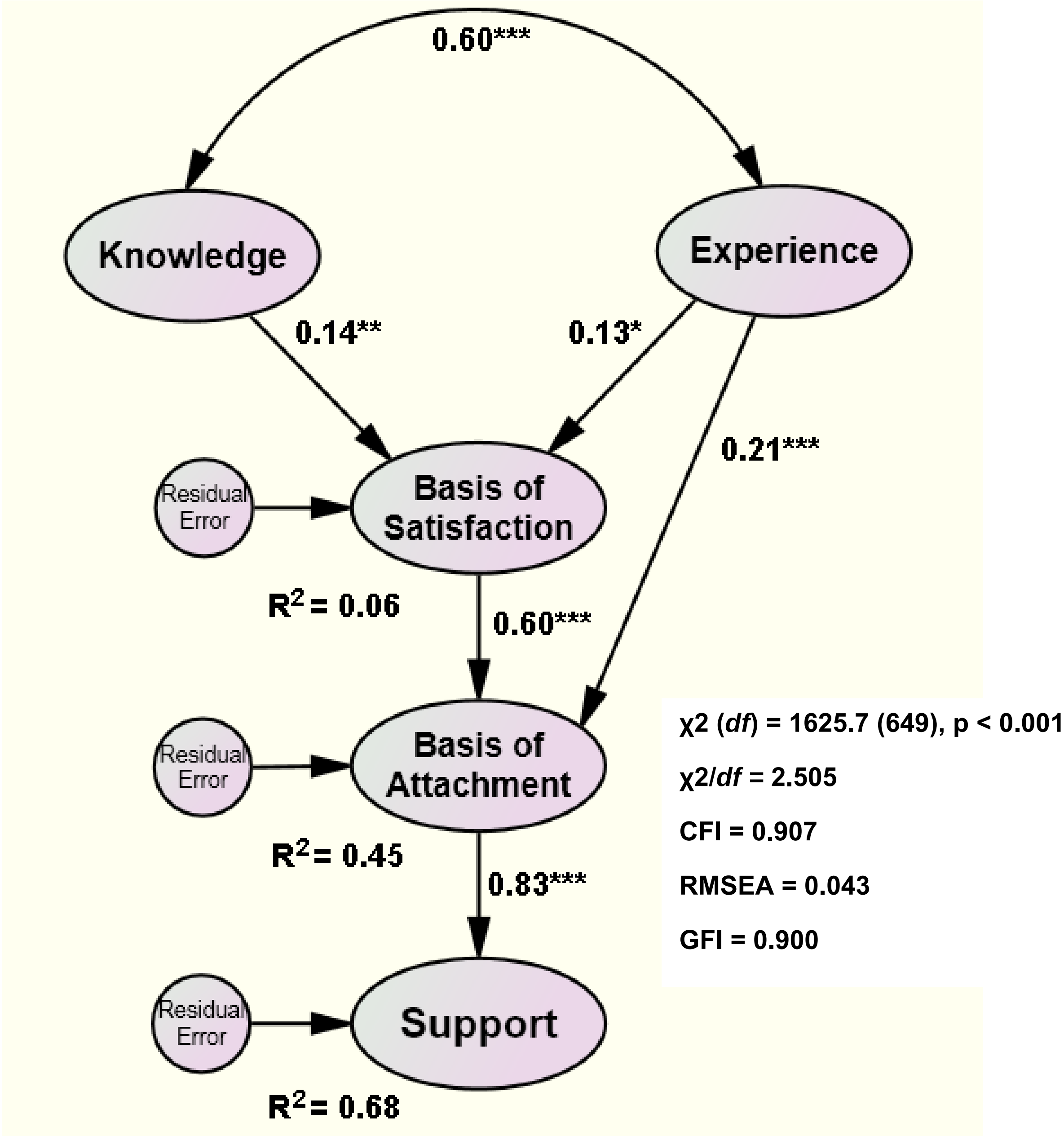
Model	Parameter	Unstandardized Estimate [1]	Standard Error	Critical Ratio [2]	Standardized Estimate	p [3]
Baseline + Tree Canopy Density (100' Radius) (Final)	Basis of Satisfaction <--- Experience	0.112	0.056	1.993	0.118	*
	Basis of Satisfaction <--- Knowledge	0.070	0.027	2.603	0.141	**
	Basis of Attachment <--- Experience	0.343	0.072	4.757	0.214	***
	Basis of Satisfaction <--- Density	0.171	0.057	2.984	0.115	**
	Basis of Attachment <--- Basis of Satisfaction	1.004	0.112	8.996	0.594	***
	Support <--- Basis of Attachment	1.329	0.123	10.794	0.822	***
	Knowledge <--> Experience	0.079	0.008	9.377	0.575	***
Baseline + Tree Canopy Density (250' Radius) (Final)	Basis of Satisfaction <--- Experience	0.114	0.056	2.043	0.120	*
	Basis of Satisfaction <--- Knowledge	0.071	0.027	2.661	0.143	**
	Basis of Attachment <--- Experience	0.344	0.072	4.791	0.214	***
	Basis of Satisfaction <--- Density	0.121	0.054	2.265	0.087	*
	Basis of Attachment <--- Basis of Satisfaction	1.001	0.111	9.122	0.595	***
	Support <--- Basis of Attachment	1.330	0.122	10.858	0.823	***
	Knowledge <--> Experience	0.079	0.008	9.386	0.572	***
Baseline + Tree Canopy Density (500' Radius) (Final)	Basis of Satisfaction <--- Experience	0.116	0.061	1.902	0.116	
	Basis of Satisfaction <--- Knowledge	0.073	0.027	2.667	0.147	**
	Basis of Attachment <--- Experience	0.380	0.078	4.878	0.226	***
	Basis of Satisfaction <--- Density	0.105	0.066	1.579	0.060	
	Basis of Attachment <--- Basis of Satisfaction	0.997	0.110	9.027	0.592	***
	Support <--- Basis of Attachment	1.325	0.122	10.833	0.823	***
	Knowledge <--> Experience	0.076	0.009	8.934	0.579	***

1. Estimates for parameters with single-headed arrows are factor loadings and estimates for parameters with double-headed arrows factor covariances.
2. The critical ratio (C.R.) is the parameter estimate divided by its standard error.
3. * $p < 0.05$
   ** $p < 0.01$
   *** $p < 0.001$

mediated effects of *Basis of Satisfaction* on *Support* have opposite signs (MacKinnon, Krull, and Lockwood 2000, Tzelgov and Henik 1991). To test this idea, the two constructs were isolated from the other three constructs and the model re-estimated. In this case, the standardized path coefficient for the direct effect of *Basis of Satisfaction* on *Support* was significant and positive (0.43). That is, a level of *Basis of Satisfaction* one full standard deviation above the mean predicts a *Support* level 0.43 standard deviations above the mean; greater levels of satisfaction are associated with greater levels of support for tree canopy protection.

Also as an experiment, the model in Figure 5.7 was re-tested (1) without the direct relationship between *Basis of Satisfaction* and *Support* and (2) with the covariance relationship between *Basis of Satisfaction* and *Basis of Attachment* modified to become a directed effect from *Basis of Satisfaction* to *Basis of Attachment*. This was theoretically justifiable, because according to Ajzen and Fishbein's Theory of Reasoned Action (1980), the "belief-oriented" measures making up *Basis of Satisfaction* could be predictive of the "attitude-oriented" measures making up *Basis of Attachment*. Therefore, the initially hypothesized model was modified to show a regression path from *Basis of Satisfaction* to *Basis of Attachment* instead of a covariance, and with the regression path from *Basis of Satisfaction* to *Support* removed.

The respecified model and the results are shown in Figure 5.8 and Table 5.3. The recursive model was estimated using the maximum likelihood method, and was identified. The new chi-square value on the respecified model ($\chi 2$ = 1579.6, *df* = 646) was also statistically significant, thus rejecting H_0 that states that the model is an exact fit. Assuming that the $\chi 2$ statistic may not be a good indicator of fit due to correlations of observed variables, variables with high proportions of unique variance, sample size, and any non-normality of observed variables, other fit indices were then evaluated. These were: $\chi 2/df$ = 2.445, CFI = 0.912, RMSEA = 0.043, and GFI = 0.902, which were very similar to the previous model and indicative of an acceptable fit for this model (Bollen 1989). No modification indices stood out indicating the need to add regression paths or covariances between pairs of variables. An examination of correlation residuals indicated the same three problematic pairs of variables as in the measurement model (absolute values of the residuals are shown in parentheses): Q6e and Q18a (0.138); Q12k and Q18e (0.154); and Q6e and Q18f (0.152). A fourth pair of variables also had a residual exceeding 0.10 (0.111): Q18d (*Residential developers should cut down fewer trees when building new subdivisions in Knox County*) and Q12k (*Road widening projects should include more tree preservation and/or tree planting*). As discussed before, the presence of four values



* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$

Figure 5.8. Respecified baseline analysis of theoretical model without tree canopy density variables.

just barely exceeding the recommended cutoff of 0.10 out of 703 pairs of correlation residuals did not indicate a need to be concerned about proceeding with this model, given the indication of adequate fit from the other indices above. Finally, this new version of the model showed all the standardized regression and covariance estimates to be significant and most importantly, the relationship between *Basis of Attachment* and *Support* to be below 1.00 ($\beta = 0.825$, $p < 0.001$). The positive coefficient implies that individuals with a positive attitudes about tree places were more likely to support protection of the local urban forest. As a result of the acceptable fit of this modified configuration, this version of the model was retained to be carried forward to be combined with the study's manifest variables "Urban Tree Canopy Density" (*Canopy Density*) in the next iteration of model testing.

The R^2 values and direct effects among the model's variables were reviewed in the Amos™ output (see Figure 5.8). Taken together, the four latent variables preceding *Support* (B*asis of Satisfaction*, *Basis of Attachment, Experience,* and *Knowledge* explained 68% of the variance in *Support*. As the direct antecedent of *Support*, 45% of the variance of *Basis of Attachment* was explained by *Basis of Satisfaction*, *Experience*, and *Knowledge*. The constructs *Experience* and *Knowledge* were hypothesized to covary in Figure 3.1, and the Amos™ output confirmed this relationship as significant in this model configuration ($\Phi = 0.573$, $p < 0.001$). *Experience* and *Knowledge* both had significant positive direct relationships with *Basis of Satisfaction* ($\beta = 0.125$, $p < 0.05$ and $\beta = 0.144$, $p < 0.01$, respectively), but only explained 6% of the variance of *Basis of Satisfaction*. This means that the more experience an individual had with landscaping and tree care, the more likely this person would find various attributes of trees to be important. Likewise, the more knowledge that a person had about trees, the greater probability that this person would find attributes of trees to be important. *Experience* had a slightly greater direct effect on *Basis of Attachment* ($\beta = 0.213$, $p < 0.001$). This means that the more experience an individual had with landscaping and tree care, the higher the probability that he/she would have a positive attitude about tree places. *Knowledge* about trees, however, did not have a significant effect on *Basis of Attachment,* as shown in the estimation of the initial Baseline version of this model.

A distinct advantage that SEM has over traditional regression analysis is that it allows the calculation of indirect effects of independent variables on the dependent variable. An indirect effect implies a causal hypothesis whereby an independent variable causes a mediating variable which, in turn, influences a dependent variable (Sobel 1990).To assist the comparison of between models, Table 5.4 presents the indirect effects of each model's independent variables on *Support* (*Basis of Attachment* is not shown as it had a direct effect only on *Support*). Recall that when *Basis of Satisfaction* and *Support* were isolated from the other study constructs, a positive regression coefficient of 0.43 was indicated. However, an examination of the indirect effects shows that *Basis of Satisfaction* actually has a somewhat larger indirect effect on *Support* (0.49) when placed in the Baseline model. Also, it is interesting to note that *Experience* has a much larger indirect effect on *Support* than does *Knowledge*. This means that if a person has engaged in landscaping or tree care oriented activities in the past year, he or she would be more likely to support tree protection policies than if they simply were knowledgeable about tree care and management.

Structural Regression Model for the Five Latent Variables and Tree Canopy Density

The final structural model from the previous section was combined with tree canopy density data measured in "buffer zones" around each respondent's address. The manifest variable "Urban Tree Canopy Density" (*Canopy Density*) was inserted into the previous model as an exogenous manifest variable preceding the variables *Basis of Attachment* and *Basis of Satisfaction* as posited in Figure 3.1. The theoretical models that contain the *Canopy Density*

Table 5.4. Indirect Effects of Model Components on Support for Local Tree Protection and Maintenance Policies [1]

Model [2]	Canopy Density	Basis of Satisfaction	Experience	Knowledge
Baseline	NA	0.492[4]	0.237[4]	0.071[4]
Baseline + Canopy Density (100')	0.056[4]	0.488[4]	0.233[4]	0.069[4]
Baseline + Canopy Density (250')	0.042[5]	0.490[3]	0.235[4]	0.070[4]
Baseline + Canopy Density (500')	0.029	0.487[4]	0.243[3]	0.072[4]
Baseline + Canopy Density (1000')	NA	NA	NA	NA

1. Standardized effects
2. Number in parenthesis is the radius of the circular buffer zone drawn around each parcel.
3. $p = 0.001$ (two-tailed)
4. $p < 0.01$ (two-tailed)
5. $p < 0.05$ (two-tailed)

manifest variable use a dataset that was created by merging the survey data with the GIS-generated tree canopy density data for each respondent's property. A range of buffer zone radii were tested: 100', 250', 500', and 1,000'. The buffer zones were created by drawing a circle with the specified radius around the centroid of each parcel (see Figure 4.3 for an example). *Canopy Density* was calculated as a percentage of tree cover over the area of each buffer zone. Figure 5.9 shows the configuration of the model that was tested with the range of buffer zone sizes.

<u>Model with 100-Foot Radius Buffer Zones</u>

The structural regression model shown in Figure 5.9 was tested using a measurement of 100' for the radii of the circles drawn around the centroids of the survey respondents' properties (total area for each circle equals 31,281 square feet or 0.72 acre). The dataset used for this analysis contained 793 cases (as opposed to the n=800 in the previous model iterations) because no tree density data were available for 7 of the cases. The results are shown in Figure 5.10 and Table 5.3. One regression path specified in this hypothesized model was shown to be insignificant (based on the probability level of 0.05; $p > 0.05$): *Canopy Density → Basis of Attachment*. The fact that *Canopy Density → Basis of Attachment* did not have a significant relationship was an important finding because the study's hypothesis H1 states that *Basis of Attachment* mediates the relationship between *Canopy Density* and *Support.* Therefore, **hypothesis H1 is only partially supported.**[24] *Canopy Density* does not have a direct relationship with *Basis of Attachment*, as shown in Figure 3.1, but *Basis of Attachment* still mediates the relationship between *Canopy Density* and *Support* in combination with *Basis of Satisfaction.* This is not a surprising finding. St. John and others (1986) found that perception of environmental conditions and "objective neighborhood attributes" (such as open space and cleanliness) were much more correlated with overall neighborhood satisfaction than with neighborhood attachment. This would be similar to how homeowners perceive urban forest canopy and how their evaluation of it would influence *Basis of Satisfaction*. Also, the fact that *Experience* has a stronger relationship with *Basis of Attachment* than *Basis of Satisfaction* is of

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[24] H1 states: "Urban tree *Canopy Density* in the place where people live is positively and directly related to *Basis of Attachment* to urban trees, which mediates the relationship between *Canopy Density* and *Support* for urban tree protection and management strategies."

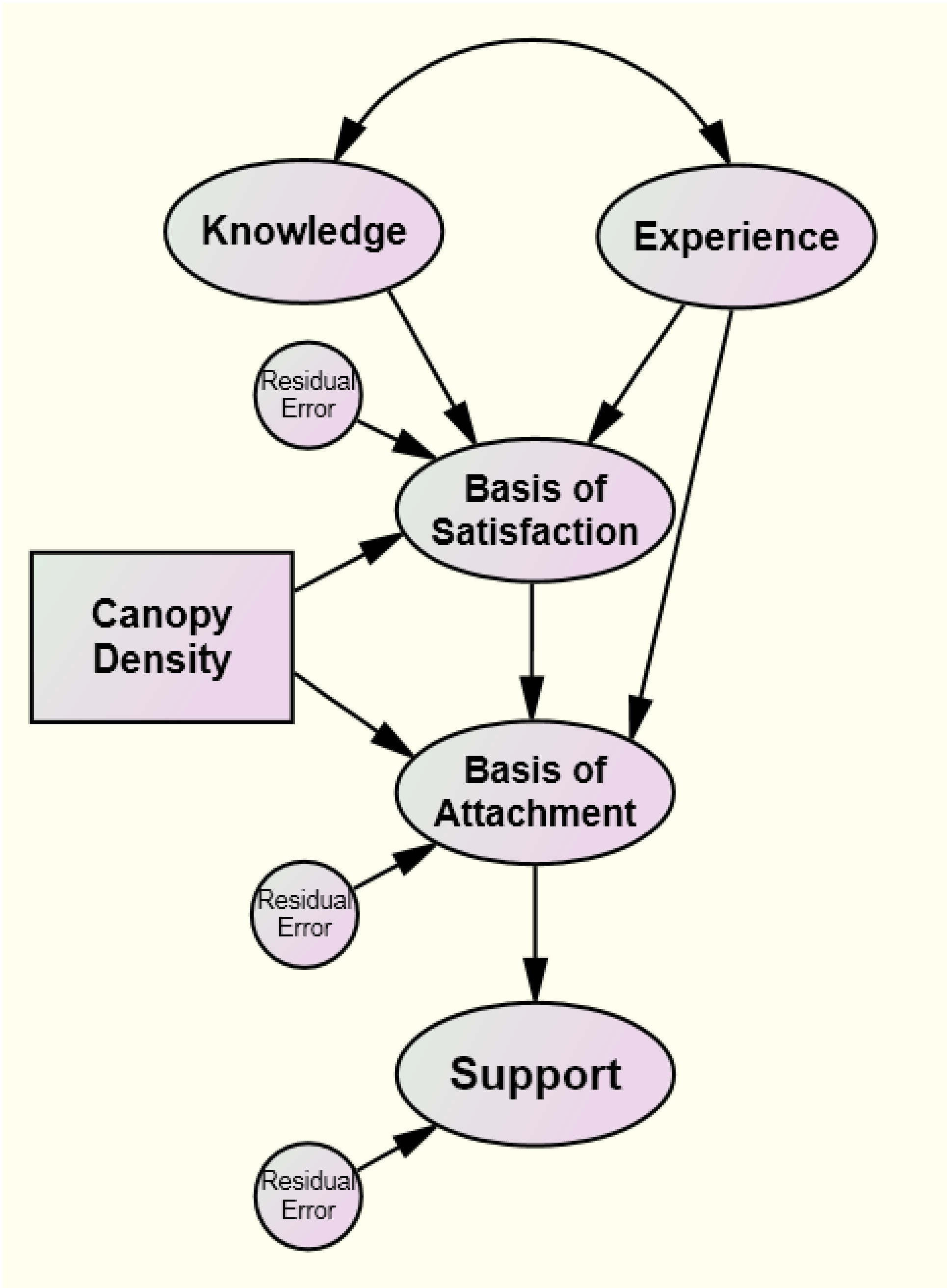
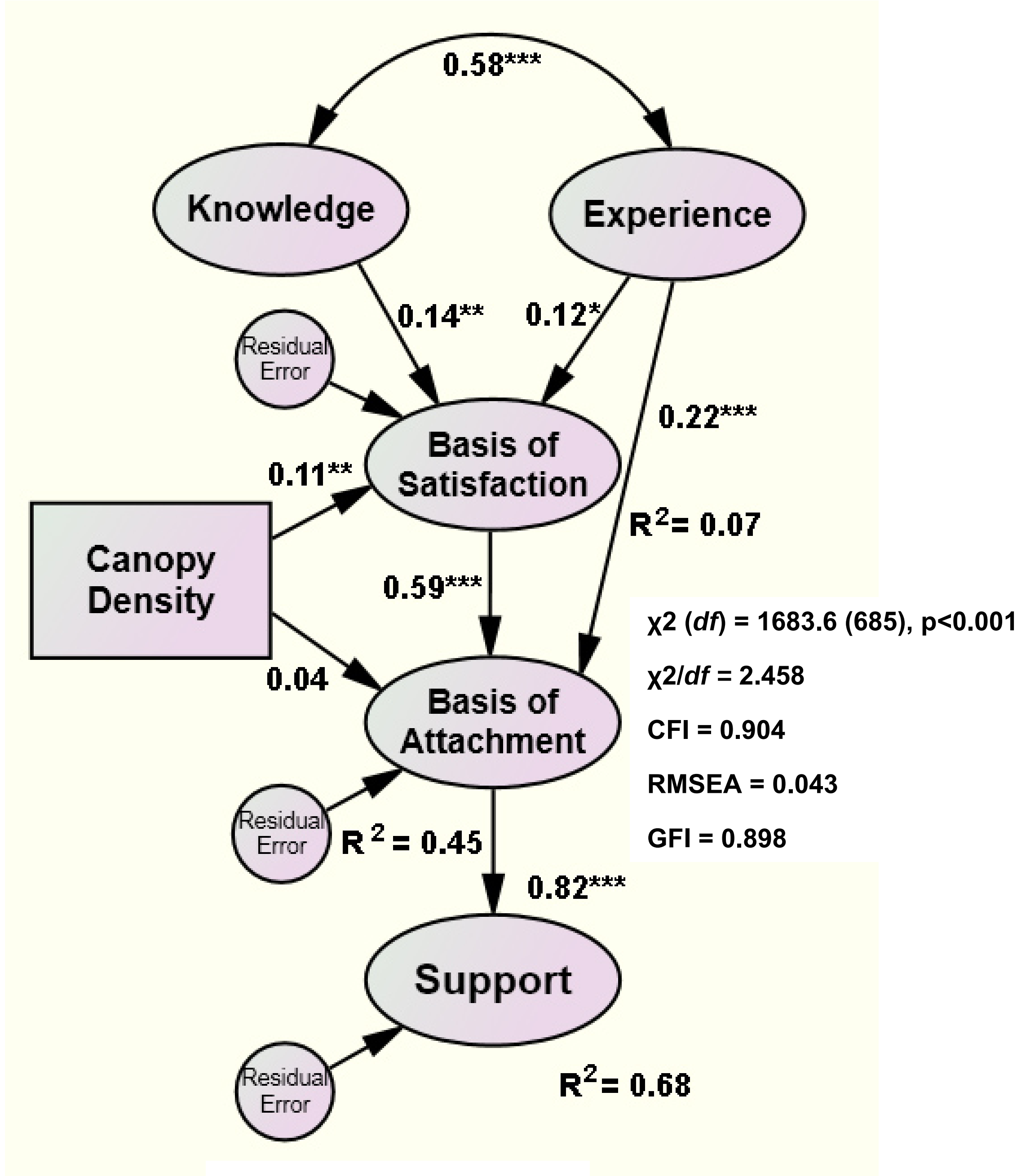


Figure 5.9. Theoretical model incorporating tree canopy density.



* p < 0.05
** p < 0.01
*** p < 0.001

Figure 5.10. Analysis of theoretical model with tree canopy density measured in buffer zones with 100' radii around parcel centroids.

interest. White, Virden, and van Riper (2008) demonstrated the significance of prior experience-use history (in the form of use of outdoor recreational areas) in the development of place attachment to natural protected areas. However, it would intuitively seem that *Experience* would also have a similar influence on one's awareness of the importance of trees as represented by the *Basis of Satisfaction* construct.

The respecified model was run without the relationship *Canopy Density* → *Basis of Attachment*, as shown in Figure 5.11.The recursive model was estimated using the maximum likelihood method, and was identified. The new chi-square value for the respecified model ($\chi2$ = 1684.8, *df* = 686) was also statistically significant, thus rejecting H_0 that states that the model is an exact fit. Assuming that the $\chi2$ statistic may not be a good indicator of fit due to correlations of observed variables, variables with high proportions of unique variance, sample size, and any non-normality of observed variables, other fit indices were then evaluated. These were: $\chi2/df$ = 2.456, CFI = 0.904, RMSEA = 0.043, and GFI = 0.898, which were very similar to the previous model and indicative of an acceptable fit for this model (Bollen 1989). Overall, the fit of this respecified model was not significantly different than the previous iteration. However, all the regression and covariance estimates are now significant and no modification indices stood out *Density* (see Figure 5.11 and Table 5.4). Taken together, the four latent variables with *Canopy Density* explained 67.6% of the variance in *Support*, which was a little bit less than the Baseline model without *Canopy Density* (R^2 = 68.0% in the Baseline model). Therefore, although *Canopy Density* had an indirect effect on *Support* (β=0.056, $p < 0.01$) through *Basis of Satisfaction* and *Basis of Attachment*, it did not contribute to the model through helping to better explain the variation of *Support.* As the direct antecedent of *Support*, 44.9% of the variance of *Basis of Attachment* was explained by antecedent variables, which again was slightly less than the Baseline model without *Canopy Density* (R^2 = 45.4% in the Baseline model). In this model, 6.6% of the variance of *Basis of Satisfaction* was explained by *Canopy Density* and *Knowledge*, as compared to 5.7% in the Baseline model. Modification indices did not show that there was misspecification in the model which indicated a need to freely estimate the path between *Canopy Density* and *Support* in order to improve model fit. Also, the addition of *Canopy Density* caused the following changes in indirect effects of the model's variables on *Support* as compared to the Baseline model: *Basis of Satisfaction d*ecreased very slightly from 0.492 to

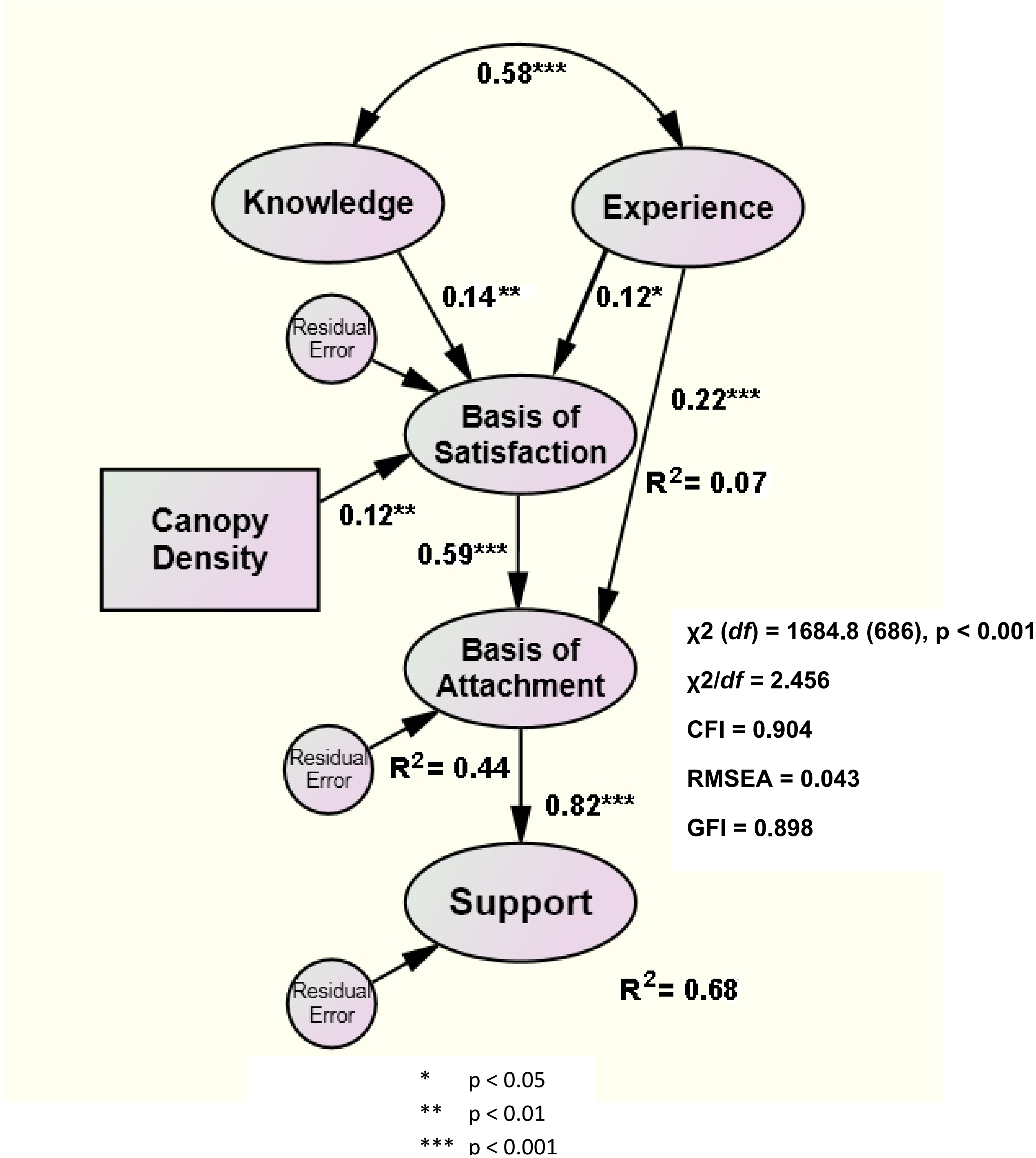


Figure 5.11. Analysis of respecified theoretical model with tree canopy density measured in buffer zones with 100' radii around parcel centroids.

0.488 ($p < 0.01$); Experience decreased from 0.237 to 0.233 ($p < 0.01$), and *Knowledge* decreased from 0.071 to 0.0.69 ($p < 0.01$).

Model with 250-Foot Radius Buffer Zones

The final SR model estimated from analysis of buffer zones with 100-foot radii (Figure 5.11) was retained and re-tested using a measurement of 250' for the radii of the circles drawn around the centroids of the survey respondents' properties (total area for each circle equals 196,250 square feet or 4.5 acres). The dataset used for this analysis contained 797 cases (as opposed to the n=800 in the model iterations prior to adding *Canopy Density*) because no tree density data were available for 3 of the cases. The results are shown in Figure 5.12 and Table 5.3. The recursive model was estimated using the maximum likelihood method, and was identified. The chi-square value ($\chi 2$ = 1691.9, *df* = 686), was statistically significant, thus rejecting H_0 that states that the model is an exact fit. Assuming that the $\chi 2$ statistic may not be a good indicator of fit due to the correlations of observed variables, variables with high proportions of unique variance, sample size, and any non-normality of observed variables, other fit indices were then evaluated. These were: $\chi 2/df$ = 2.466, CFI = 0.905, RMSEA = 0.043, and GFI = 0.898, which were indicative of an acceptable fit for this model (Bollen 1989). Standardized regression estimates and significance of the path weights were also estimated (shown on Figure 5.12) and were all found to be significant. No modification indices stood out indicating the need to add regression paths or covariances between pairs of variables. An examination of correlation residuals did not reveal any absolute values exceeding 0.10 except for the same four pairs discussed previously.

A review of the R^2 and the direct, indirect, and total effects among the model's variables indicated slight changes in the relationships due to the addition of the manifest variable *Canopy Density* (see Figure 5.12 and Table 5.4). Taken together, the four latent variables with *Canopy Density* explained 67.7% of the variance in *Support*, which was 0.1% more than the model using buffer zones with 100' radii, but a little less than the R^2 of 68.0% for baseline model without the variable *Canopy Density.* Therefore, although *Canopy Density* had an indirect effect on *Support* (β=0.042, $p < 0.05$) through *Basis of Satisfaction* and *Basis of Attachment*, it did not contribute to the model through helping to better explain the variation of *Support.* As the direct antecedent of *Support*, 45.2% of the variance of *Basis of Attachment* was explained by *Canopy Density*,

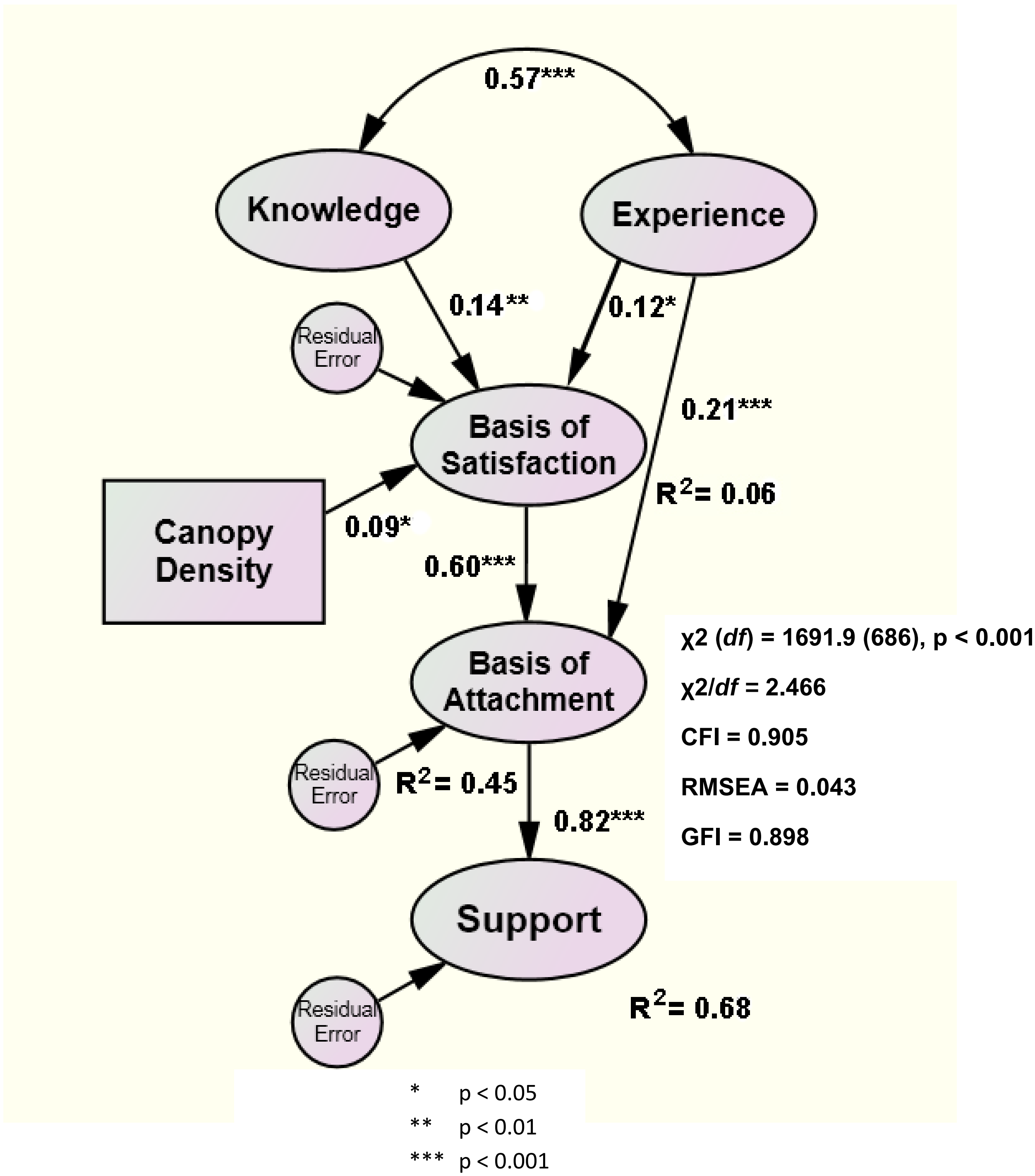
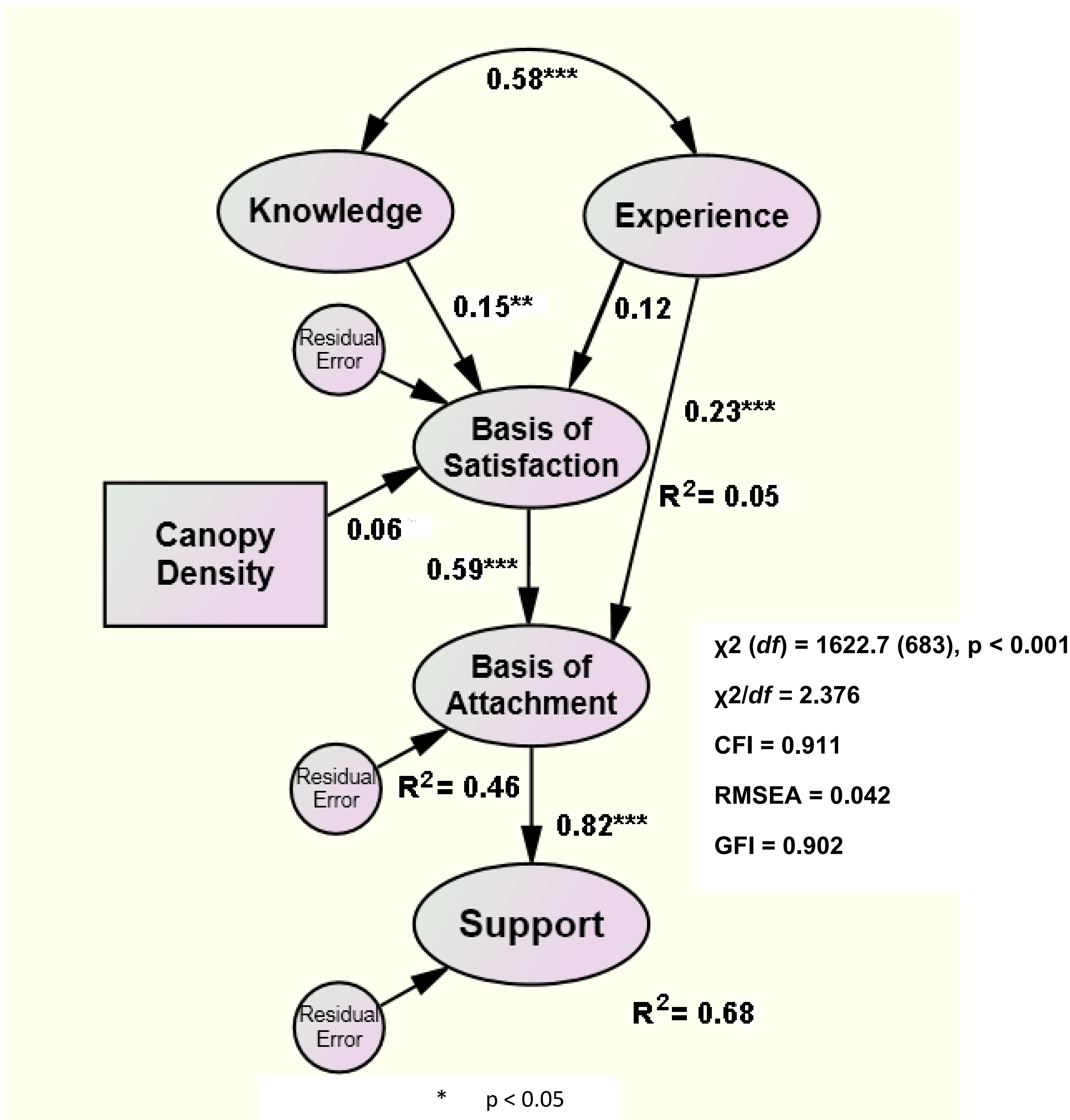


Figure 5.12. Analysis of theoretical model with tree canopy density measured in buffer zones with 250' radii around parcel centroids.

Basis of Satisfaction, *Experience*, and *Knowledge*, which was 0.3% more than the model using 100’ radii and 0.2% less than the Baseline model. In this model, 6.2% of the variance of *Basis of Satisfaction* was explained by *Canopy Density* and *Knowledge,* which was 0.4% less than the model with 100’ radii and 0.5% more than the Baseline model. As before, modification indices did not show that there was misspecification in the model which indicated a need to freely estimate a direct path between *Canopy Density* and *Support* in order to improve model fit. Also, the increase of the buffer zone size from 100’ radii to 250’ radii caused the model’s latent variables to have a very slight increase in indirect influence on *Support*; this was likely due to the model compensating for the slight decrease in the indirect effect of *Canopy Density* on *Support.*

Model with 500-Foot Radius Buffer Zones

The final SR model estimated from analysis of buffer zones with 100-foot radii (Figure 5.11) was retained and re-tested using a measurement of 500’ for the radii of the circles drawn around the centroids of the survey respondents’ properties (total area for each circle equals 785,000 square feet or 18 acres). The dataset used for this analysis contained 794 cases (as opposed to the n=800 in the model iterations prior to adding *Canopy Density*) because no tree density data were available for 6 of the cases. The results are shown in Figure 5.13 and Table 5.3. The recursive model was estimated using the maximum likelihood method, and was identified. The chi-square value ($\chi 2$ = 1622.7, *df* = 683), was statistically significant, thus rejecting H_0 that states that the model is an exact fit. Assuming that the $\chi 2$ statistic may not be a good indicator of fit due to correlations of observed variables, variables with high proportions of unique variance, sample size, and any non-normality of observed variables, other fit indices were then evaluated. These were: $\chi 2/df$ = 2.376, CFI = 0.911, RMSEA = 0.042, and GFI = 0.902, which were indicative of an acceptable fit for this model (Bollen 1989). However, the outcome of this SR analysis shows the path from *Canopy Density* to *Basis of Satisfaction* to be no longer significant. This finding indicates that the use of a 500’ radius for the buffer zones is not relevant to the conceptualization of the theoretical model used in this study. This is not too surprising, given that the “visual zone” from one’s home likely does not reach the boundary of the 18-acre circle defining the buffer zone for this study. Orford (2002) also found that the threshold for measuring “street level locational attributes” such as parks and schools fell off dramatically beyond 100 meters (328 feet). Again, the reader may refer to Figure 5.13 and Table 5.3 for



* p < 0.05
** p < 0.01
*** p < 0.001

Figure 5.13. Analysis of theoretical model with tree canopy density measured in buffer zones with 500' radii around parcel centroids.

comparison purposes, but I will reserve commenting further on the findings for this iteration of the model as it is not relevant.

Model with 1,000-Foot Radius Buffer Zones

Because there was no significant relationship between *Canopy Density* and *Basis of Satisfaction* in the model above using 500' radii, it was predicted that the same model with 1,000' radii would also have no significant relationship between these two variables. To verify this assumption, the model was estimated using the maximum likelihood method using the buffer zones with 1,000' radii. The outcome indicated that this size buffer zone also did not produce a significant relationship between *Canopy Density* and *Basis of Satisfaction.*

Summary of Modeling with the Five Latent Variables and Tree Canopy Density

The model using 100' radii for the measurement of tree canopy density around the respondents' properties was retained. This decision was based on the observation that this distance had the strongest relationship between *Canopy Density* and *Basis of Satisfaction.* As reported above, this model also had an acceptable fit, as determined by fit indices and examination of the residuals.

Referring to the final model with 100' radii shown in Figure 5.11, one can see that in addition to hypothesis H1 being partially supported (as discussed on page 121), **hypotheses H2, H3, H4, and H5 are fully supported.** For H2, *Canopy Density* was positively and directly related to *Basis of Satisfaction*, which then directly influenced *Basis of Attachment*. *Basis of Attachment* then was directly related to *Support*, which means that *Basis of Attachment* and *Basis of Satisfaction* mediate the relationship of *Canopy Density* with *Support*. For H3, the final model showed *Basis of Satisfaction* and *Basis of Attachment* to be positively related; SEM indicated a better model fit was obtained when *Basis of Satisfaction* was specified as a causal antecedent to *Basis of Attachment*, as opposed to the two variables covarying. H4 was supported since *Experience* was found to directly influence *Basis of Satisfaction* and *Basis of Attachment*; *Basis of Attachment* was then directly related to *Support*, mediating the relationship of *Basis of Satisfaction* with *Support.* Finally, for H5, *Knowledge* was shown to directly influence *Basis of Satisfaction*, which the mediated the relationship between *Knowledge* and *Basis of Attachment. Basis of Attachment* is then directly related to *Support.*

Summary

This chapter discussed the data analyses procedure and results of testing the hypotheses introduced in Chapter 3. A summary of the descriptive statistics of the data was first provided. The mean, standard deviation, skewness, and kurtosis values of each scale item were reported. Two (2) of the 46 variables were dropped because of a concern for non-normality: Q3d (skew of 3.86 and kurtosis of 12.92) and Q3l (skew of 3.20 and kurtosis of 8.25). These two indicators of the construct *Experience* measured “Attended a class or a workshop about gardening (yes/no)” and “Donated time or money to a gardening, tree or landscape group (yes/no),” respectively.

The remainder of this chapter was devoted to factor analysis and structural equation modeling, and was conducted in two steps. Step 1 employed CFA to assess fit for each of the five models representing each of the constructs separately, followed by CFA of the total measurement model where all five latent variables were allowed to intercorrelate freely with one another (i.e., non-directional associations). CFA of the individual constructs (“Experience with Trees and Landscaping” – *Experience*, “Tree Knowledge” – *Knowledge*, “Basis of Satisfaction with Tree Places” – *Basis of Satisfaction*, “Basis of Attachment to Tree Places” – *Basis of Attachment*, and “Support for Local Tree Protection and Maintenance Policies” – *Support*) refined the number of indicators and covariances among the indicators to obtain the best fit for each factor, thus ensuring convergent validity. Step 2 modified the measurement model to represent the study hypotheses, beginning with the SR model showing the regression structure (i.e., directional associations) among the latent variables only, followed by the SR model with latent variables and the urban tree *Canopy Density* manifest variable using “buffer zones” ranging from 100’ to 1000’ radii.

During the CFA process in Step 1, the number of indicator manifest variables for the five latent variables was further reduced from 44 to 38. The *Experience* construct lost three indicator variables: Q1 (“Frequency working in yard growing up”), Q3g (“Contacted a public agency or official about home gardening, tree care or general landscaping”), and Q3l (“Donated time or money to a gardening, tree or landscape group”). The *Basis of Attachment* construct lost one indicator variable: Q12h (“Trees should not be planted in business districts because they block store signs ").[25] Next, a measurement model was developed where all five latent variables were allowed to freely correlate; this model provided an acceptable fit to the data: $\chi2$ (799) = 1922.2; $\chi2$/df = 2.443; CFI = 0.912; RMSEA = 0.042; GFI = 0.903. Finally, discriminant validity was tested by examining intercorrelations and also by using the $\chi2$ difference ($\chi2_d$) test, which tested for significant differences in $\chi2$ values while constraining the correlations between each of the ten pairs of latent variables. One pair of constructs, *Support* and *Basis of Attachment* was found to have an elevated correlation of 0.90, which exceeded the recommended maximum value of 0.70 (MacKenzie et al. 2005). But since the indicators for these two constructs were theoretically distinct, this was not perceived as a serious problem. Another pair of constructs, *Experience* and *Basis of Satisfaction*, was found to have an insignificant $\chi2_d$ value which indicated a problem with the distinctiveness of these two constructs; however, this did not present a problem as the final model did not show a strong relationship between *Experience* and *Basis of Satisfaction*.

Finally, the structural model was evaluated using the SEM approach in Step 2. After checking the model's fit for the latent variables only, *Canopy Density* was added using 100', 250', 500', and 1,000' radii. The 100' radius was found to have the best fit of the four radii. The fit indices of the final structural model, using buffer zones of 100' radii, were within acceptable limits: $\chi2$ (*df* = 686) = 1684.8; $\chi2$/df = 2.456; CFI = 0.904; RMSEA = 0.043; GFI = 0.898. The data supported or partially supported all five of the proposed hypotheses as shown in Table 5.5. Although the addition of *Canopy Density* did not improve the R^2 of *Support*, it did have a significant indirect effect on *Support* (β=0.056, p <0.01) through *Basis of Satisfaction* and *Basis of Attachment* Also, the addition of the *Canopy Density* variable had mixed effects on model fit. Its addition slightly improved $\chi2$/*df* (decreasing from 2.505 to 2.456). However, RMSEA stayed the same (0.043) and CFI very slightly decreased from 0.907 to 0.904 and GFI very slightly decreased from 0.900 to 0.898. These changes, though, were not dramatic and all these values fell within the recommended ranges to indicate acceptable model fit.

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[25] In total, as a result of principal component analysis, analysis of skew and kurtosis, and CFA, Experience went from 14 to 8 indicators, Knowledge stayed at 9 indicators, Basis of Satisfaction went from 10 to 9 indicators, Basis of Attachment went from 7 to 6 indicators, and Support stayed the same at 6 indicators.

Table 5.5 Summary of study hypotheses and outcomes.

Hypothesis	**Result**	**Comments**
H1. Urban tree *Canopy Density* in the place where people live is positively and directly related to *Basis of Attachment* to urban trees, which mediates the relationship between *Canopy Density* and *Support* for urban tree protection and management strategies.	Partially Supported	*Canopy Density* was not positively related to *Basis of Attachment.* However, *Basis of Attachment* mediated the relationship of *Canopy Density* with *Support* through the presence of the antecedent variable *Basis of Satisfaction* which was directly and positively influenced by *Canopy Density.*
H2. Urban tree *Canopy Density* in the place where people live is positively and directly related to *Basis of Satisfaction* to urban trees, which mediates the relationship between *Canopy Density* and *Support* for urban tree protection and management strategies.	Supported	*Canopy Density* was positively and directly related to *Basis of Satisfaction*, which then directly influenced *Basis of Attachment*. *Basis of Attachment* then was directly related to *Support*, which means that *Basis of Attachment* and *Basis of Satisfaction* mediate the relationship of *Canopy Density* with *Support.*
H3. *Basis of Attachment* to urban trees and *Basis of Satisfaction* with urban trees are positively related.	Supported	The hypothesized model showed these two variables to be intercorrelated; however, a better model fit was obtained when *Basis of Satisfaction* was specified as a causal antecedent to *Basis of Attachment.*
H4. *Basis of Attachment* and *Basis of Satisfaction* mediate the relationship between *Experience* with trees and landscaping and *Support* for tree protection and management strategies.	Supported	*Experience* directly influences *Basis of Attachment* and *Basis of Satisfaction*, which mediate the relationship between *Experience* and *Support.*
H5. *Basis of Attachment* and *Basis of Satisfaction* mediate the relationship between *Knowledge* of trees and landscaping and *Support* for tree protection and management strategies.	Supported	*Knowledge* directly influences *Basis of Satisfaction*, which mediates the relationship between *Knowledge* and *Basis of Attachment. Basis of Attachment* is then directly related to *Support.*

Findings supported the assertion that place-based contexts are significant in the prediction of community willingness to support higher levels of urban forest protection. The modeling results imply that although the presence of urban trees around one's yard leads one to place greater importance on various attributes of trees (the homeowner's *Basis of Satisfaction*), this does not automatically lead to *Support* for strong tree ordinances. Tree places must also have strong meanings to this person (as indicated by *Basis of Attachment*), and this is directly predicted by *Experience* a person has caring for trees around his/her home. Also, *Knowledge* about trees directly influences *Basis of Satisfaction*, thus indirectly influencing *Support*. An in-depth discussion of these results will be presented in the next chapter.

CHAPTER VI

DISCUSSION AND CONCLUSIONS

Urban forests have long been credited for a wide range of ecological and socio-economic benefits to cities and suburban areas, from sequestering carbon to increasing property values to reducing soil runoff. In addition to the strictly ecological and economic benefits of urban forests, other more intangible contributions of urban trees to quality-of-life metrics have been used by city managers, planners, and foresters to raise awareness of the importance of healthy urban forest and policies to maintain them. With the majority of U.S. citizens living in human-built (urban/suburban) environments in the 21st century, urban trees and passive green space provide a touchstone to natural environments to which city dwellers still maintain powerful bonds. These bonds arise from the need for the invaluable psychological counterpart urban trees provide to the man-made urban and suburban setting, through their ability to camouflage harsh scenery, beautify the landscape, and break up the monotony of endless sidewalks and miles of highways and streets.

The integration of social and ecological science has been proposed as a way to gain a better understanding of the mechanisms that drive support for environmental protection policies such as those that affect the urban forest, but this area has been often been under-theorized with negative implications for research and urban environmental planning. It is notable that geographic information systems (GIS) software has rapidly evolved as a user-friendly, widely-available tool to measure and analyze observed urban conditions to characterize the distribution of the urban forest and elucidate core policy issues to improve environmental sustainability of cities and regions. However, the many and diverse sets of contingencies that shape socio-spatial relationships impacting the effectiveness of locally-derived environmental policies continue to confound the implementation of strategies for reversing tree canopy loss on a regional level.

With a view to refining social theoretical approaches for improving the understanding of the dynamics of urban forest cover as an outcome of local environmental policy and public values, this study has explored how “place-based” measures of tree canopy are related to locally held attitudes about, beliefs of, knowledge about, and life experience with trees. Using social and biophysical data from a major urban area in Southern Appalachia (Knox County, Tennessee), a model was devised that incorporated attitude-behavior theory and place theory to identify hypothesized predictors of support for urban forest protection policy. A mailed survey was employed to collect the social data and 800 completed responses from homeowners were used for the data analyses. Also, publicly-available tree canopy density data around the respondents' homes was linked to the social data for the final analysis.

In this chapter, I will consider links between the results of the empirical and conceptual components of this research study. The study's purpose, as well as the significant theoretical and empirical findings are reviewed. Finally, I consider the study's implications for future research on social and biophysical indicators of support for environmental policy such as urban tree protection legislation.

Overview of Hypotheses and Findings

The purpose of this study was to build a theoretical account that builds on attitude-behavior theory and place theory to explain variation in the level of support for urban tree canopy protection. Specifically, the hypothesized model takes into account the fact that ecological functioning of the urban forest begins with human interactions at the smallest level, between individual trees and one person. The management of single trees fit into the functioning of the local urban forest through the rolling influence of one tree on stands of trees, then upwards in scale to the functioning of trees in neighborhoods, communities, cities, and bioregions. It is hypothesized by attitude-behavior theory that individual human activity is governed by socio-psychological factors such as attitudes, beliefs, knowledge, life experience, and social structural factors. Place theory helps to define the geographical scale in which these socio-psychological factors impact ecological behavior by freeing the analysis of traditional constraints of viewing the urban forest (e.g., jurisdictional or Census Bureau terms) through the use of the "value-influenced" borders of *Sense of Place* (SOP). Place theory offers the potential to discover common place-based group identities based on shared meanings and expectations of appropriate behaviors within a particular place, and to relate SOP-derived values to different scales. Theoretically, this allows the potential crafting of "place-based" environmental policies that identify dimensions and patterns of stakeholder ways of knowing at different geographic scales of place (neighborhood, community, and region), thus bringing together and enhancing diverse ways of knowing at meaningful scales of place. The context of the current study is important because it focuses on individual homeowners in a single community and links how socio-material aspects (e.g., their subjective opinions about trees) translate with support for local environmental policy that eventually may lead to diverse ecological outcomes on larger scales.

Guided by attitude-behavior theory and place theory, a conceptual model was hypothesized to characterize the interdependencies among the place-based latent variables (*Basis of Attachment* and *Basis of Satisfaction*), *Knowledge*, *Experience*, and *Support*). The configuration of these latent variables was based on a generalized attitude-behavior model building on the ideas presented by Dunlap and Jones (2002) that environmental concern is a multidimensional concept. Drawing from attitude theory, environmental concern has been depicted as an outcome of individual beliefs, knowledge, attitudes, and behavior. Measures of these attitudinal components have been tested in the literature, largely through survey research, using models that are hypothesized to predict environmental behavior (e.g., recycling), behavior intentions (e.g., willingness to incur personal cost to support an environmental policy), and public opinion about environmental risk (e.g., climate change). In addition to the seminal work by Dunlap and Jones, environmental concern literature of interest to the current research draws from important work by Routhe and others (2005), Stern and Dietz (1994), and Stern and others (1995).

Dunlap and Jones emphasize that although attitude theory was traditionally conceptualized in social-psychological studies on an individual level, environmental sociologists have recognized the opportunity to deploy similar concepts in policy-relevant studies on a macro level. The framework developed by Routhe and others (2005), addressed this through a model depicting theoretical linkages among attitudinal factors and public support for environmental policy (in that case, building a dam to meet public water supply needs). Their theorizing built on the work of Dunlap and Jones as well as the conceptual foundations of environmental concern research developed in part by Ajzen and Fishbein and their Theory of Reasoned Action (1980). The current research, in turn, has borrowed the ideas of Routhe and his colleagues, by applying a similar approach for theorizing about the relationship of attitudinal constructs to support for urban forest protection.

The “tripartite” conceptualization of attitudes (i.e., affective, conative, and cognitive) is a common thread found in environmental concern literature, and forms an important link to another body of theorizing: place theory, which treats *Sense of Place* as another multidimensional attitude consisting of affective, conative, and cognitive components. Work by Jorgensen and Stedman (2001, 2006), as well as Brehm and others (2006) explore this link, and provide the basis for the inclusion of biophysical variables as additional predictors of environmental concern. The hypothetical model presented in this dissertation research builds on this idea, using measures of urban forest canopy density as a biophysical predictor of public support for urban forest protection policy. The urban tree canopy density (*Canopy Density)* was measured at varying radii around the respondents' properties. *Canopy Density* was inserted into the model to conceptualize *Place Attachment* and *Place Satisfaction* through the latent variables *Basis of Attachment* and *Basis of Satisfaction*, respectively, as theorized by Stedman (2002, 2003a) in his place-based model. In particular, I was interested in measuring the direct, indirect, and total effects of the manifest variables and latent variables (*Basis of Attachment, Basis of Satisfaction*, *Knowledge*, and *Experience*) on support for urban tree canopy protection legislation (*Support*).

The current study aims to contribute to the environmental concern literature through the development of a theoretical framework suggesting how the social-psychological foundation of environmental concern for the local urban forest (drawing from attitude-behavior theory) may also include *Sense of Place*. Place theory offers the potential to discover common place-based group identities based on shared meanings and expectations of appropriate behaviors within a particular place, which are derived from bonds that people have developed with their physical environment. In addition, the focus on the urban forest using attitude theory and place theory is a little-explored area of sociological research which has important implications for policies governing bioregional health, since SOP-derived values may be applied to different regional scales.

GIS was used as a tool to help bridge the gap between the socio-cultural world of socially constructed place-based meanings, attitudes, and intentions, through the use of a quantitative approach that allows the inclusion of these place-based factors in an empirical analysis of drivers of community support for environmental legislation. GIS analytic techniques were used to map survey respondent's locations, and using existing spatial data, measure urban tree canopy density around their properties. This biophysical data were linked to their survey responses in order to test this study's theoretical model. This methodology allowed the opportunity to: (a) empirically test theoretical propositions previously posited by environmental social scientists on the determinants of environmentally significant attitudes and behavior; (b) introduce an external variable, urban tree canopy density, as an integrative factor that tracks social variables to represent place-based identities based on shared meanings of tree places; and (c) develop and analyze a more fully specified model predicting willingness to support urban tree protection and management policies.

Structural equation modeling (SEM) was used to test this model, which offers an unparalleled treatment of measurement errors and their possible correlations. By taking measurement errors into account, SEM gives more reliable and accurate estimates of parameters than multiple regression (Jöreskog and Sörbom 1993). SEM also allows the opportunity to assess regression relationships simultaneously, allowing one to compare the relative importance of indicator variables.

The hypothesized conceptualization of public support for urban forest protection was corroborated by the findings. The results of this investigation provides evidence that there is an association between the physical environment (urban tree *Canopy Density*) and *Support*, as operationalized through the concepts urban tree *Place Attachment* and urban tree *Place Satisfaction.* This study contributes theoretically and methodologically to the advancement of knowledge in the field of sociology and theorizing in the areas of attitudes, behavior, and *Sense of Place* by addressing ways that spatial analysis may be significant to understand support for environmental policy to protect urban trees and how *Sense of Place* contributes to attitude theory research.

The major contributions of this hypothesized model and methodology are as follows:

- Attitude-behavior theorizing was expanded to include place-based attitudes as conceptualized by *Basis of Attachment* and *Basis of Satisfaction*, thus combining important elements of both traditional attitude-behavior theorizing used by environmental sociologists and psychologists with place theory as practiced by those in the fields of geography, phenomenology, urban planning, anthropology and cognitive psychology.
- Attitude theory and place theory were combined within the context of urban forest protection. Urban forests are of utmost importance to regional ecosystem health because of the way they are connected by a large number of biophysical and human processes to larger ecosystems.
- Findings from this research illuminate how GIS technology may be used to understand the effect of SOP on community attitudes toward tree canopy protection and other land

use decisions. This technique may provide direction to policy makers on how to link public acceptance for government initiatives on a community level to improvements in environmental sustainability on a regional level.

Among the various findings that have been revealed in the analysis of the study model measuring support for urban forest protection policies in Knox County, Tennessee, there are three that are most noteworthy.

First, the physical environment is shown to play a significant role in influencing peoples' relationship with *place*, namely their basis of satisfaction with and attachment to a particular type of place – tree places. This basis of satisfaction and attachment then was shown to influence their level of support to protect tree places. Assessing the distribution and frequency of these indicators serves as a starting point to identify potential landscape values important to a community, in order to adapt proposed land management policies to be consistent with the local community's concerns and policy preferences. The current research concludes that *Canopy Density* measured in a 100' radius around the survey respondent's home may be used as an integrative indicator (indirectly) for *Support* for tree protection and management policies. However, the addition of *Canopy Density* was not found to improve the model's ability to explain variation in *Support* as compared to the model which did not include *Canopy Density*. SEM results also showed that *Canopy Density* has a direct influence on *Basis of Satisfaction* with tree places. This finding suggests that the higher the tree canopy density around the respondent's house, the more satisfied he/she is with the presence of trees and the stronger support he/she has for local tree canopy protection policies. The contribution of this finding to the policy-making arena is to offer a heuristic that might guide participants in locally based urban tree canopy management processes to gain an understanding of the origins of site-specific shared place meanings and policy preferences. The understanding that *Canopy Density* is positively related to *Support* leads to the idea that if a community wants to garner more support for urban forest protection policies, they could instigate this process by planting more street trees, for example. This action would serve to potentially increase citizens' awareness of urban trees' benefits, which leads to more support for policies to protect the overall urban tree canopy.

Second, the hypothesized model in the current study shows how attitudes about tree places (*Basis of Attachment*), beliefs about the importance of trees (*Basis of Satisfaction*), experience with tree care (*Experience*), and knowledge about tree care (*Knowledge*) may be used to indirectly predict *Support* for tree protection and management policies, and the relative importance of these predictors. *Basis of Attachment* had the strongest positive influence on *Support*, followed by an indirect positive influence by *Basis of Satisfaction*, *Experience*, and then *Knowledge*. These findings lend support to the idea of taking into account the hierarchical nature of individual perceptions, community context (biophysical and cultural), and individual vs. collective action. Although we can focus on individual experience, knowledge, preferences, and attitudes in a "methodological individualistic" fashion, environmental policymakers must consider *Sense of Place* as a critical component of overarching "functioning" of a community's support for environmentally sustainable development. Increasing knowledge and awareness of the values of a healthy urban forest, or even planting more trees, are valid starting points for improving ecological functioning of a community, but *Sense of Place* that values urban trees must ultimately be present if community planners wish to gain traction in garnering support for urban forest protection policies, such as through various intervention techniques. As shown in the current research and the research it builds on, the operationalization of the concept of *Sense of Place* among the several interacting factors predicting environmental concern tends to be more sophisticated than what can be detected from aggregation of individual data reflecting "lots and lots of people" through their characteristics, values and perceptions. The ability of sociology to strike a balance between the macro and micro level of analysis is what distinguishes it in its recognition of the dangers of embracing reductive scientific laws on one hand, and trivial observations on the other hand.

Finally, the use of urban tree *Canopy Density* as a biophysical indicator for *Support* becomes less significant when measured in buffer zones greater than a 100' foot radius from the center of the homeowner's property, and insignificant at distances greater than 500'. This corresponds roughly with the "visual zone" of place-based biophysical features, as represented by urban trees (Acharya and Bennett 2001). This finding shows that explicit distance variables are, in fact, very important and informative in understanding the value of incorporating environmental variables in the hypothesized model.

Implications of Findings for Urban Forest Policy Decision-Making

Sociology is used to examine this broader public discourse about the goals and objectives of a community's management of urban trees. The key is to develop a systematic approach to identifying and quantifying social values in a pluralistic fashion without placing too much emphasis on technical, computational approaches to measuring “environmental values.” (Konijnendijk 2000, Norton and Steinemann 2001) First, we must recognize that because people look at larger-scale environmental problems from local viewpoints, a place-based approach should be used that is aware of the particularities of local conditions and the function of local sub-systems in larger environmental systems. This approach also lends itself to case-based science to develop a management strategy rather than using an over-arching top-down theory to “apply” to a variety of local situations. Second, the challenge of achieving a more regional approach to sustaining the urban forest cover calls for more systematic approach to the evaluation of ecosystem-level environmental change. It is increasingly evident that isolation and modeling of small portions of environmental processes in computer simulations (i.e. “normal science”), are not always practical in today’s world. A strategy needs to be developed that seeks ways to organize diverse goals as a starting point for a more holistic analysis.

In the act of seeking to uncover and explain predictors of urban forest protection in Knox County, many new questions and avenues for future research have been raised. First, it is evident that human-ecological functioning of a community occurs outside of the summation sign and the analysis of these functions is necessarily hierarchical: individuals are located within neighborhoods which in turn are located within communities and regions. This does not mean that measures derived from individuals cannot be used, only that they must be used in conjunction with measures of community-level functioning. The statistical techniques for analyzing hierarchical or nested data are available and are probably more relevant to the analysis of large data-sets rather than the micro-evaluations discussed in the current study. What needs to be developed is a method for making summative statements across projects so that we have a basis for comparison. To some extent, this has already been achieved through the development of the NEP scale and other attitudinal measures, and the modeling which shows significant relationships among biophysical features, landscape meanings, and “place protectiveness.” The challenge for environmental sociologists is therefore to take advantages of the advances in spatial analysis methodologies in recent years and develop valuation techniques which facilitate the inclusion of community- and bioregion-level factors in evaluations of support for urban forest protection policies.

Other methodological issues to be addressed in future research include broadening the scope of analysis. Although this study focused on understanding the social and biophysical structural backdrop to support for urban forest policy, future work would benefit from a deeper focus on cultural, normative, and collective-action perspectives that attach meaning to how residents frame their commitment to protecting their local urban forest. It is interesting to note that the timeframe of the survey used in this study coincided with the rollout of proposed legislation for urban forest protection in Knox County. Although the County Commission eventually rejected the proposed ordinance, the heightened public awareness of this possibility undoubtedly contributed to the survey's response (42%). In addition to the timing of studies such as this, broadening of this study's scope also depends on having better and more detailed environmental and physical data, such as percent impermeable surface, differentiation among tree heights and types, measures of other forms of low-lying vegetation, and presence of street trees around residents' homes. Also, this research has been limited in the content of the initial survey questions. This pre-chosen framework shaped this research and the hypothesized attitude dimensions, as well as the other latent and manifest variables. Had more precise SOP measures of urban tree *Place Attachment* and urban tree *Place Satisfaction* been included, the results may have been completely different from the current approach which inferred these SOP measures from the *Basis of Attachment* and *Basis of Satisfaction* attitudinal constructs and urban tree *Canopy Density*, as theorized by Stedman (2003a). Finally, another limitation of this study could be construed to be the time lag between the collection of social survey data (2005-2006) and the LiDAR measurement of Knox County tree canopy (2007 for West Knox County and 2010 for East Knox County).

In summary, the relatively small impacts of numerous private property owners and their surrounding communities can add up to big environmental problems on a regional scale. In other words, a number of environmental problems result from what economist Alfred Kahn (1966) called "the tyranny of small decisions." The tyranny occurs when many decision makers make small decisions that might seem individually optimal but prove to be cumulatively less than optimal. Consequently, there is a growing recognition that communities need to respect and work with larger ecological systems in promoting proper ecosystem functioning through support and enforcement of policies that promote urban forest health. Exposing citizens to knowledge and experiences that places them in contact with natural features play an essential role. However, it is hoped that place-based research of environmental concern helps to elucidate the challenges of understanding the gap between simplistic intervention techniques and community-level, environmentally sustainable action. The current research suggests ways that concepts in the “cognitive hierarchy” may include *Sense of Place* measures to help bridge this gap.

The investigation of *Sense of Place* has its origins in phenomenological inquiry. An important consideration for measuring SOP constructs is the establishment of the geographic or conceptual terrain of interest; the local “urban forest” as perceived by homeowners around their house was the typology used in the current study. However, a single case study cannot begin to capture the full range of meanings that may be associated with psychological bonds a homeowner may have with the local urban forest. Ultimately, our ability to gain a better understanding of the relationships between social structure, attitudes, urban tree canopy structure, and support for urban tree protection policies will require employing long-term social and biophysical data, adapting existing methods to novel settings, and increasing the model’s sensitivity to complex social and ecological interactions in urban areas.

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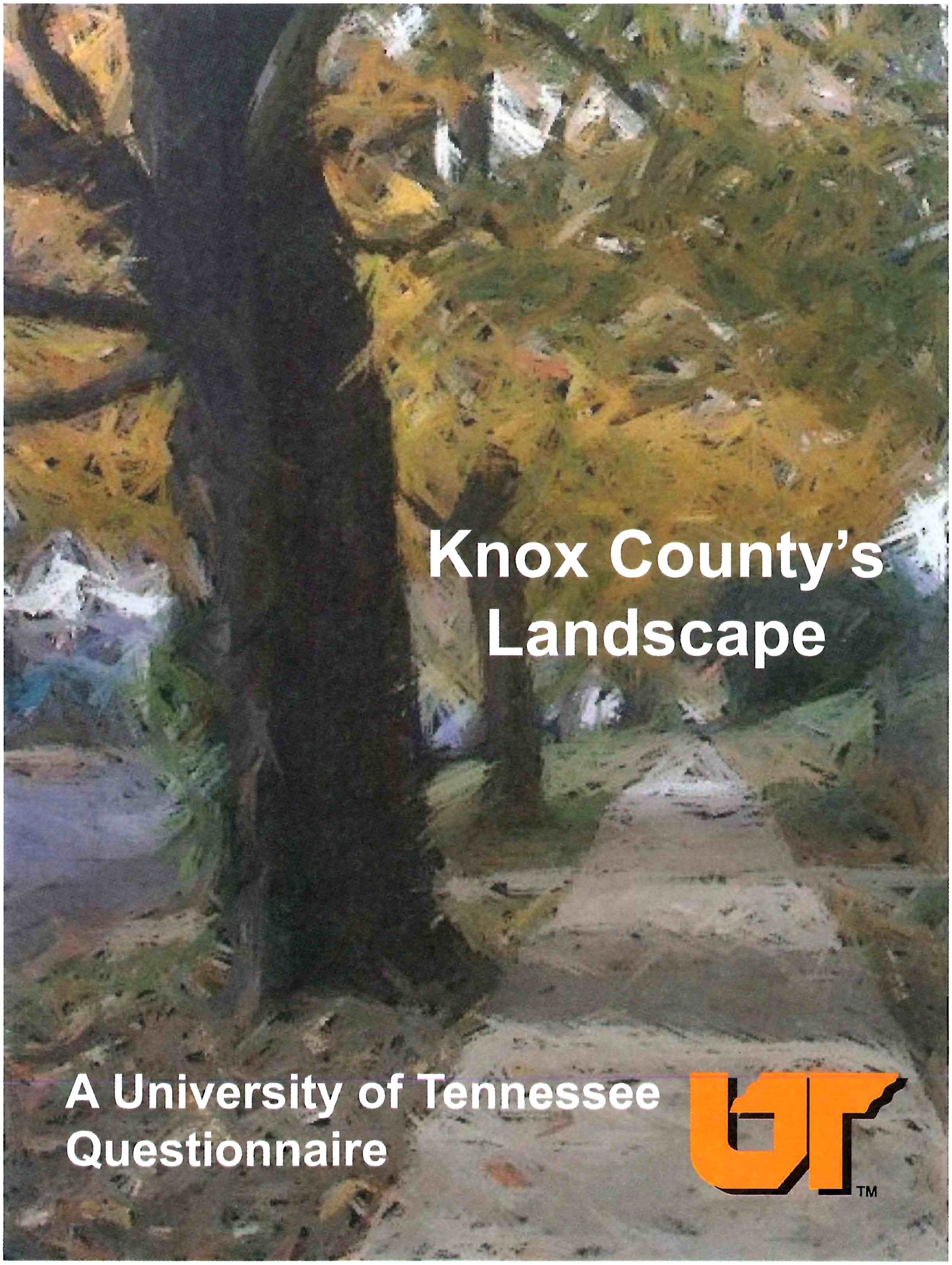
APPENDIX: THE SURVEY INSTRUMENT


Knox County's
Landscape
A University of Tennessee
Questionnaire
TM

The University of Tennessee (UT) Waste Management Research and Education Institute is conducting this research to gather public opinion about maintenance and protection of trees in Knox County. The study is being sponsored by the Tennessee Department of Agriculture. Results will be used to help design effective public policy and programs. Return of this survey will constitute your informed consent to participate. THANK YOU FOR VOLUNTEERING YOUR HELP!

The first set of questions is about your experience with and knowledge about gardening, landscaping, and trees.

Q1 How often did you work in the garden, care for trees, or do other lawn or landscaping activities when you were growing up? Please circle your answer.

a. Very Often b. Often c. Occasionally d. Rarely e. Never

Q2 Have you planted a tree in the past five years?

1. Yes___ 2. No___

Q3 In the past year, I *or a member of my current household* have (check all that apply):

____ a. Planted flowers, vegetables, herbs, or maintained a home garden.
____ b. Talked to others about gardening, tree care or landscaping.
____ c. Read articles or watched programs about gardening, tree care or landscaping.
____ d. Attended a class or a workshop about gardening, tree care or landscaping.
____ e. Hired someone to maintain my lawn, garden, trees or general landscape.
____ f. Visited an arboretum or nursery.
____ g. Contacted a public agency or official about home gardening, tree care or general landscaping.
____ h. Planted a tree on my property.
____ i. Mulched around a tree on my property.
____ j. Pruned or had work done on a tree on my property.
____ k. Cut down or removed a tree on my property.
____ l. Donated time or money to a gardening, tree or landscape group.

Q4 **How much of Knox County's landscape do you think is covered by trees? (Please check or circle your answer.)**

____ a. 10%
____ b. 25%
____ c. 50%
____ d. 75%
____ e. 90%

Q5 ***Urban forests*** **are trees in populated areas, such as cities, golf courses, and residential subdivisions. When comparing Tennessee's urban forests to other southeastern states, do you think that Tennessee has:**

____ a. More urban forest than most other southeastern states

____ b. About the same amount of urban forest compared to other southeastern states

____ c. Less urban forest than most other southeastern states

Q6 **Please tell us how much you know about the following aspects of trees and tree care by circling your answer.**

	Very knowledgeable	Somewhat knowledgeable	Know little or nothing
a. Planting a tree	1	2	3
b. Caring for a tree	1	2	3
c. Trimming a tree	1	2	3
d. Protecting a tree from insects and pests	1	2	3
e. Cutting down a tree	1	2	3
f. Identifying native trees to this area	1	2	3
g. Identifying diseased trees	1	2	3
h. Selecting a suitable tree for your landscape	1	2	3
i. Buying a healthy tree	1	2	3

Q7 **Next, please tell us how much you know about the following organizations and policies that relate to tree care and maintenance. (Circle your answer.)**

	Knowledgeable	Somewhat knowledgeable	Know little or nothing
a. The Knoxville Tree Board	1	2	3
b. The City of Knoxville's Master Street Tree Plan	1	2	3
c. Proposal to create a Knoxville-Knox County Tree Board	1	2	3
d. Proposal for a Knoxville-Knox County Tree Conservation and Planting Plan	1	2	3
e. The National Arbor Day Foundation	1	2	3

The following questions will help us understand opinions that you may have about trees and your feelings in general about trees in your neighborhood.

Q8 **Please tell us how important the following characteristics of trees are to you by circling your answer.**

	Very important	Somewhat important	Not important	Undecided or unsure
a. Trees provide shade	1	2	3	4
b. Trees mark seasonal change	1	2	3	4
c. Trees increase privacy	1	2	3	4
d. Trees decrease energy costs	1	2	3	4
e. Trees slow wind	1	2	3	4
f. Trees improve air quality	1	2	3	4
g. Trees reduce street noise	1	2	3	4
h. Trees provide wildlife habitat	1	2	3	4
i. Trees produce attractive blooms	1	2	3	4

Q9 **Have you removed *or had someone else remove* an older tree from your residential property in the past five years?**

1. No ____ (Skip to **Q12**.)

2. Yes ____ (Go to **Q10** below.)

Q10 Why was the tree removed? (Check all that apply.)

____ a. The tree was dead or almost dead
____ b. I was afraid the tree would fall on my house
____ c. I did not like to clean up leaves, sap, fruit, or branches
____ d. The tree attracted too many birds or insects
____ e. The tree blocked views
____ f. There was danger of the roots damaging my foundation
____ g. The surface roots got in the way of walking or mowing
____ h. The tree was not attractive
____ i. I wanted to let more sunlight into my yard or house
____ j. I prefer yards with few or no trees
____ k. I was worried that a stranger could hide behind it
____ l. It aggravated my allergies
____ m. Other (please specify)________________________

Q11 Out of all the reasons you gave in **Q10**, which was the most important? (Specify the letter.)________

Q12 Please tell us the extent to which you AGREE or DISAGREE with each of the following statements by circling your answer based on the following scale:

1 – Strongly Agree (SA)
2 – Mildly Agree (MA)
3 – Undecided or Unsure (U)
4 – Mildly Disagree (MD)
5 – Strongly Disagree (SD)

	SA	MA	U	MD	SD
a. Trees inspire community pride.	1	2	3	4	5
b. Trees are worth protecting if they have historical value.	1	2	3	4	5
c. Trees in cities help people to feel calmer.	1	2	3	4	5
d. It is annoying when people get upset about cutting down trees, because we can always plant more.	1	2	3	4	5
e. Trees cannot be protected on construction sites in a cost-effective manner.	1	2	3	4	5
f. Trees should not be planted in cities because their roots crack the sidewalks.	1	2	3	4	5
g. Trees should be replaced instead of saved when building a house or developing a commercial property.	1	2	3	4	5
h. Trees should not be planted in business districts because they block store signs.	1	2	3	4	5
i. Trees enhance property values.	1	2	3	4	5
j. The utility company does a good job trimming tree branches to clear a zone for overhead wires.	1	2	3	4	5
k. Road widening projects should include more tree preservation and/or tree planting.	1	2	3	4	5
l. Humans have a responsibility to protect trees.	1	2	3	4	5
m. We need to have more trees in Knox County to cool and clean the air.	1	2	3	4	5
n. The local government should do more to protect trees.	1	2	3	4	5
o. Local governments should not be responsible for planting trees.	1	2	3	4	5

Q13 Did you know that the City of Knoxville worked for ten years, beginning in the 1990s, to plant 1,000 trees per year along city streets?

1. No ____ (Skip to **Q15.**)

2. Yes ____ (Go to **Q14.**)

Q14 If yes, how did you learn about the new street trees that the City planted?

____ 1. I just noticed new street trees
____ 2. Knoxville News-Sentinel
____ 3. Metro Pulse
____ 4. Television
____ 5. Email/internet
____ 6. Talking with other people
____ 7. Other (please specify) ________________

Q15 Do trees have a particular personal, symbolic, or spiritual meaning to you?

1. Yes___ 2. No___ 3. Unsure___

Q16 If you were looking for a new place to live (such as a house or apartment), how important would it be for the property to have trees?

____ a. Very important
____ b. Somewhat important
____ c. Somewhat unimportant
____ d. Not at all important

Q17 Does your current property have one or more mature trees that are taller than your residence?

1. Yes___ 2. No___ 3. Unsure___

Q18 Please tell us the extent to which you AGREE or DISAGREE with each of the following statements by circling your answer based on the following scale:

1 – Strongly Agree (SA)
2 – Mildly Agree (MA)
3 – Undecided or Unsure (U)
4 – Mildly Disagree (MD)
5 – Strongly Disagree (SD)

	SA	MA	U	MD	SD
a. More city/county funding is needed for planting trees in public areas (such as along streets, in schoolyards, and in parks).	1	2	3	4	5
b. It is important for utility districts to enforce proper trimming of street trees and protection of tree roots.	1	2	3	4	5
c. Our local government is spending enough money on saving or planting trees in Knox County.	1	2	3	4	5
d. Residential developers should cut down fewer trees when building new subdivisions in Knox County.	1	2	3	4	5
e. Commercial developers should not be required to protect old trees or plant new trees in Knox County.	1	2	3	4	5
f. There should be stronger rules about protecting large old trees on private residential property.	1	2	3	4	5

Q19 If given the chance, what is the likelihood that you would donate your time or money to support planting trees in Knox County?

____ a. Very likely
____ b. Somewhat likely
____ c. Not very likely
____ d. Not at all likely

Now we would like to know what you think about environmental protection, in general. Please check or circle you answer.

Q20 Have you ever switched brands of a product because of environmental reasons?

1. Yes___ 2. No___

Q21 Please tell us the extent to which you AGREE or DISAGREE with each of the following statements by circling your answer based on the following scale:

1 – Strongly Agree (SA)
2 – Mildly Agree (MA)
3 – Undecided or Unsure (U)
4 – Mildly Disagree (MD)
5 – Strongly Disagree (SD)

	SA	MA	U	MD	SD
a. I would support vehicle emissions testing for Knox County.	1	2	3	4	5
b. Environmental protection laws hurt the economy.	1	2	3	4	5
c. I find it hard to get too concerned about environmental issues.	1	2	3	4	5
d. Being out in nature is a stress reducer for me.	1	2	3	4	5
e. People have the right to modify the natural environment to suit their needs.	1	2	3	4	5
f. Too much development of shorelines and other natural areas will cause irreversible damage.	1	2	3	4	5

Now, we'd like to learn more about you. Please be assured that your answers will be KEPT CONFIDENTIAL and will ONLY be used for group comparisons.

Q22 In what year were you born? ________

Q23 What is your gender? 1. Male______ 2. Female_______

Q24 Which of the following categories BEST describes you?

_______ 1. Caucasian (non-Hispanic)
_______ 2. African-American
_______ 3. Hispanic or Latino
_______ 4. American Indian
_______ 5. Asian or Pacific Islander
_______ 6. Other (please indicate) ________________

Q25 How would you BEST describe your political affiliation?

_______ 1. Conservative Republican
_______ 2. Moderate Republican
_______ 3. Independent
_______ 4. Moderate Democrat
_______ 5. Liberal Democrat
_______ 6. Unsure or Undecided
_______ 7. Other (please indicate) ________________

Q26 What was your total household income before taxes in 2004?

___ 1. Under $25,000
___ 2. $25,000 to $49,999
___ 3. $50,000 to $74,999
___ 4. $75,000 to $99,999
___ 5. Over $100,000

Q27 Which of the following categories best represents your highest level of education?

_______ 1. Less than High School
_______ 2. Some High School
_______ 3. High School Graduate or GED
_______ 4. Some College/Technical School
_______ 5. College Graduate
_______ 6. Graduate School or more

Q28 Do you or a family member own your home, or do you rent?

______ 1. Own/Paying a mortgage ______ 2. Rent

Q29 What BEST describes the type of dwelling where you live?

______ 1. House
______ 2. Apartment building
______ 3. Condominium
______ 4. House divided up into apartments
______ 5. Duplex
______ 6. Townhouse
______ 7. Other (please indicate)__________
____

Q30 What is your zip code? __________

Q31 About how many YEARS have you lived in your current residence?_______

Q32 Where do you live in Knox County?

______ 1. Town of Farragut
______ 2. City of Knoxville
______ 3. Elsewhere in Knox County
______ 4. Other_____________________

Q33 Which electric utility company serves your residence?

_______ 1. Knoxville Utilities Board (KUB)
_______ 2. Lenior City Utilities Board (LCUB)
_______ 3. Not sure
_______ 4. Other________________________

Q34 Are you a member of an organization that works to protect the environment?

1. Yes___ 2. No___

Q35 Do you *or someone in your household* work for a business that is involved with land development or road building in Knox County?

1. Yes___ 2. No___

Please turn to the back cover to write any comments you may have.

Thanks you so much for helping on this important study. Your responses will help us better understand public opinion about protection and management of trees in Knox County. We realize that you may have other comments or opinions that you weren't able to express in this survey. We invite you to write ANY comments you have in the space below.

☐ Please check here if you would like to receive a summary of this survey's results (provide contact information below).

☐ Please check here if you would like to be included in a drawing for five $25 gift certificates we are giving away to survey participants (provide contact information below).

Address:____

____

____

Email:____

Please return your completed survey using the self-addressed stamped envelope to:

Waste Management Research & Education Institute
University of Tennessee
Suite 311 Conference Center Building
Knoxville, Tennessee 37996-4134

VITA

Kimberly Davis is a native of Kingsport, Tennessee. She completed her Bachelor's degree in 1984 in Chemical Engineering and her Master's degree in Environmental Engineering in 1988 at Clemson University in Clemson, South Carolina. She earned a Doctoral Degree in Sociology at the University of Tennessee in 2011, with an emphasis in Environmental Sociology. She currently works at Spectra Tech, Inc., an environmental, engineering, and nuclear consulting firm in Oak Ridge, Tennessee. She is married to Fred Sahms and lives in Knoxville, Tennessee.